Elliott:

Electro-Therapeutics and X-Rays.

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Arbor Scientiae

PHILADELPHIA, PA.:
BOERICKE & TAFEL.
1900.

T. B. & H. B. COCHRAN, PRINTERS,
LANCASTER, PA.

PREFACE.

In the preparation of this work we have refrained from giving long, dry descriptions of the various electric batteries and their mechanical construction, a subject which not one physician in a hundred ever wades through, and have given only just sufficient to enable the student or physician to understand how the various currents are generated.

The chief object of this work is to place before the student and practitioner a "Materia Medica" of electricity, if we may be allowed the use of the term, that is, to place before them, in as brief, plain and simple manner as possible, the best and latest methods of applying the various currents.

The plan pursued is, first, to give each current, and the *general* indications calling for that particular current; second, taking up the various diseases to which electricity is applicable, and giving the *special* current called for, its strength, duration of sitting and frequency of application in as far as is practicable.

In addition to the section on Electro-Therapeutics, one on X-Rays has been given. In the preparation of this section it has been our aim to so give in minute detail all the steps necessary in preparing the apparatus (connection of Crookes tube, spark gaps, etc.), the method of taking radiographs and make fluoroscopic examinations, that even a novice by pursuing these steps will find no difficulty in employing an X-Ray apparatus.

CHARLES SINCLAIRE ELLIOTT, M. D.

Kansas City, August, 1900.

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ELECTRICITY.

The name electricity is derived from the Greek word, ἠλεκτρόν (electricity), meaning "amber," from the fact that this force was developed from amber by friction.

Electricity is one of the many forms of energy similar to light, heat, sound, etc., and has no existence *per se* apart and distinct from the matter which it affects. It is one of the great invisible forces of Nature.

We do not know what electricity is. We know it only by its effects. We know that under certain conditions of matter certain phenomena result, which we attribute to something which we call electricity. Out of the various theories and hypotheses regarding electricity, the most reasonable and generally accepted is that of potentiality. According to this theory, electricity is not an article or fluid (as some suppose), but the manifestations of an endeavor on the part of the atoms of an element to remain at an equilibrium, as water seeks its level; therefore, by disturbing this equilibrium or rest of the atoms by any means (friction, chemical action or otherwise) we produce the condition called electricity.

Although we do not know what electricity is, we do know how to produce it and how to bend it to our will, forcing it to send messages around the world, to light our streets and houses, to relieve pain, cure and alleviate diseases and produce the wonderful X-rays.

There is a vague idea that vital force and electricity are identical; in other words, that nerve energy and electric energy are one and the same thing, and, therefore, "electricity is life." Ever since Galvani's experiments with the frogs, in 1786, physiologists have been debating the question of the relations of electricity to nerve force. A great many claim that the two are identical. It cannot be denied that there is a striking analogy between the manner in which a nerve fiber transmits its influences and that in which a conducting medium conveys an electrical current. There is a resemblance between the arrangement of the axis cylinder of the nerve, surrounded by white substance and membraneous tubes, and that of an insulated electric conductor. Besides this structural resemblance, however, we find that when a current of electricity is transmitted along a nerve trunk it performs the same function, according to the nature of that nerve, as the nerve force itself. If we deny the identity of electricity and nerve force, we can only account for these facts by the hypothesis that a portion of the artificially-applied electricity is converted into nerve force. A careful study of the results obtained by many thousands of applications of electricity to the human body and other organisms constrains us to believe that this theory is correct—namely, that although electricity is not identical with nerve force, it is analagous to it, and is, under favorable conditions, converted directly into it. Nerve action is one demonstrated form of wave or molecular motion; electricity is another; and the motion of electricity seems to be more nearly allied to the nerve motion than any other.

The earliest history that we have of this force, which we know as electricity, is 600 years B. C., when the old Greek philosopher Thales discovered that when amber was rubbed it possessed the power of attracting and repelling bodies.

The ancient naturalist, Aristotle, 341 B. C., gives a description of an electrical fish belonging to the order Raicæ and family Torpedinidæ—speaking of the shocks received by

contact with it by Juan, and its power of capturing its prey among other fish. The organs generating the electricity are described by Ophian, 204 A. D.; also Scribonius, Largnd, Dioscorides and Galen all speak of its therapeutic effect; a case of gout is cited as cured by its shocks, and it is recommended for severe pains in the head.

It is supposed that there are two kinds of electricity pervading all bodies, *positive* or *vitreous*, and *negative* or *resinous;* in the unelectrified condition these fluids just neutralize each other, but may be separated by chemical action, friction, etc. These two phases have a strong affinity for each other, and are always trying to come into actual contact with and neutralize each other. When this is accomplished there is a *discharge* which leaves the electrified bodies without any charge of electricity. If the charge is sufficiently great, it will not be necessary for the positive and negative surfaces to come in actual contact before there is a discharge, as the accumulated potential will force a discharge through the air *from* positive *to* negative, in the form of a bright spark or electric flash.

From the friction of the earth upon the clouds and the clouds upon the earth, there is free electricity in the air at all times. A cloud becomes charged with positive electricity; the positive of the cloud attracts the negative of the earth, there is a flash and a report, and the electric equilibrium between the so-called positive and negative electricities is established.

The atmosphere is always charged electrically, sometimes more powerfully than the earth beneath a given locality, owing to currents being driven aside as the clouds move in the wind. The varying charge is adjusted through storms, when lightning equalizes the polarity and static capacity above.

The influence of terrestrial magnetism and atmospheric electricity over health and disease is a subject of practical interest to every physician. It is found that in fine weather the atmosphere is almost invariably charged positively; before

rain it often assumes a negative state. The rain that first falls is usually negative, although the atmosphere before and after the fall may be positive. Fogs, snow and hail, if unattended by rain, are nearly always positively charged. The earth is *always* charged negatively, while that of the air is positive. Yet, at times, the first stratum of air above the earth's surface is negatively charged, but above that it will be positive.

The changes in quantity and intensity of atmospheric electricity dependent upon storms, sunshine, humidity, dryness, and, perhaps, even on the "sun spots," are intimately connected with life, health and disease. It has been noticed, both in Europe and America, that during the great epidemics of cholera, yellow fever, etc., the death rate is in inverse proportion to the amount of positive electricity present in the affected district.

The electric condition of the atmosphere, as a causative and aggravating influence upon diseased action, has not received that attention which its importance would warrant. Many people, without divining the reason thereof, have noted the fact that headache and other unpleasant sensations frequently occurred prior to a thunderstorm. This is due to the electric influence. Thus in a condition in which the atmospheric electricity at the earth's surface is predominantly in the positive or negative state, marked effects may be noted upon the diseases prevailing.

It is claimed by some that the proximate cause of disease is electric changes, the type depending upon the polarity. For instance, a long-continued positive condition of the atmosphere predisposes to disease of an active nature, sthenic fevers, etc., while if this state prevails in moderation a tonic effect results. If the opposite condition prevails, a lowered vital action prevails; hence neuralgia and low fevers are most prevalent. This accounts for the fact that a long-continued or marked negative condition of the atmosphere is called unhealthy. In certain states of the atmosphere the negative

condition is so excessive that it is almost or quite impossible to generate electricity with the static machine to produce a spark. It is during such times diseases alarmingly prevail.

No one can doubt that the natural electrical conditions of the air we breathe influence health. Scientists assert that all atmospheric states which have been observed to have an unfavorable influence upon health are accompanied by an increase of negative electricity in the air. It is well known that before a thunderstorm an indescribable sense of malaise and oppression is felt by many individuals, and especially by those of a delicate, nervous temperament, or who are subject to rheumatism, neuralgia, etc. At such a time the atmosphere in the neighborhood of the earth is surcharged negatively, and the common expression that a thunderstorm clears the air is scientifically correct; the equilibrium of the two forces of electricity being restored by the exchange in the visible form of lightning between the lower negative and the upper positive layers of air. According to some recent observations, earthquakes appear to occasion a negative electrification of the air. In low, damp, malarial regions it is found that the atmosphere is electrified negatively, while the higher we go the more positive does the atmosphere become. Atmospheric electricity is greater during the winter months than during the summer months.

The electrical condition of the air is subject to daily variations. Every twenty-four hours there is a decrease of electricity, beginning an hour or two after midnight and continuing till shortly before sunrise, when an increase commences and goes on until some hours after sunrise, when the first maximum is attained. The electrical condition of the air then remains stationary for a short time, after which another decrease sets in until some hours after noon, when a minimum is reached. Another short pause ensues, and then a second increase takes place, attaining its maximum some hours after sunset.

The human body always possesses electricity. In a certain

sense every man, woman, or child may be considered a galvanic battery, and each will and does retain a certain amount of electricity, some more, some less. When well and vigorous, they retain a much larger charge than when the blood is impoverished and the nerve-cells are degenerated.

While the free electricity of the body is quite feeble, as to its intensity, it is not uncommonly emitted in such quantity as to produce a spark or ignite gas. The organs in which this force resides are the nerves, and it is secreted chiefly by the brain. The chief receptacles are the muscles; they represent, as it were, a Leyden jar, their external surface being negative, while the inner one is positive. The direction of the muscular current is the same as that of the nervous current. Not only the nerves and muscles, the brain and the spinal cord of living animals are possessed of electromotive force, but all tissues in which active nutrition is going on give rise to electric currents. Dr. Radcliff claims that the primary electrical condition of living muscle and nerve during the state of inaction is that of static electricity, and that the muscular current, which may pass from the muscle and nerve during that state of inaction, are only secondary phenomena.

The natural electricity of the human body, termed "animal electricity," is positive, but may be changed into negative by exposure to cold, or by sudden, rapid, and violent motion. Positive electricity is increased in winter and diminished in summer, ceasing entirely during perspiration. Animal electricity is not so well manifested in human beings as in certain fishes, as the gymnatus, the malapterurus, the torpedo, etc.

Many invalids are capable of foretelling changes in the weather by the aggravation or amelioration of their disease, and their change of symptoms will be found to correspond with the changes in atmospheric electricity from positive to negative, or *vice versa*, which immediately precedes or follows a storm. The daily and nightly rise and fall of grave symptoms attendant upon many acute diseases correspond

very nearly with the variations in terrestrial electricity, and are recognized as occurring with such regularity that the experienced practitioner can often readily predict the condition of the patient for hours in advance. There is a time when the magnetic tides are flowing out from us, and another when they are flowing in; they flow out about five o'clock in the morning, and that is the time when the most deaths occur; the body loses heat and the coldest time is just before the break of day, so it is the time of the least magnetism, and we are weakened in the amount of electrical force.

Certain physicians of Europe have attempted to fix the time of day at which most deaths occur. From many thousand cases, a Glasgow physician is inclined to believe that 6 A. M. is the favorite farewell hour; a Berlin doctor finds the time to be from 5 to 7 A. M.; another observer gives it as 5 to 7 for men and the evening hours for women; and a Paris hospital attendant has noted a lull in deaths from 7 to 11 P. M.

DEFINITIONS OF ELECTRICAL TERMS.

The use of technical terms employed has become so common that an acquaintance with their significance will prove of advantage, and being explained in a simple manner will be easily comprehended.

An *ampere* represents the amount of electricity resulting from the passage of a current of one volt over one ohm's resistance. The name is derived from the scientist Ampere. As the ampere represents too great a current strength for use in electro-therapeutics, a smaller unite, the *milliampere*, or one-thousandth part of an ampere (the unite of correct strength in medicine), has been adopted for general use by electro-therapeutists. The abbreviation, ma., for milliampere has been adopted by nearly all writers on electro-therapeutics and will be employed throughout the body of this work.

A *galvanometer* is an instrument for measuring a galvanic current and showing its direction.

A *milliampere-meter* is a galvanometer whose deflections have a definite value, and may be called a graded or absolute galvanometer; and is an instrument for accurately measuring the number of milliamperes which the patient is taking. A milliampere-meter, although not absolutely essential, is a most desirable instrument, and should be employed by every electro-therapeutist in his daily work, for it is only by such accurate, clinical observations that we can ever hope to make electro-therapy an exact science. Experience will soon convince you that the sensation of the patient is not always a reliable guide, for the electro-sensibility of different individuals varies greatly,—that is, while one may take the current strength from ten or fifteen cells and scarcely feel it, and is receiving, we will say, 5 or 6 ma., in the next patient you may get the same current strength from eight to ten cells. The

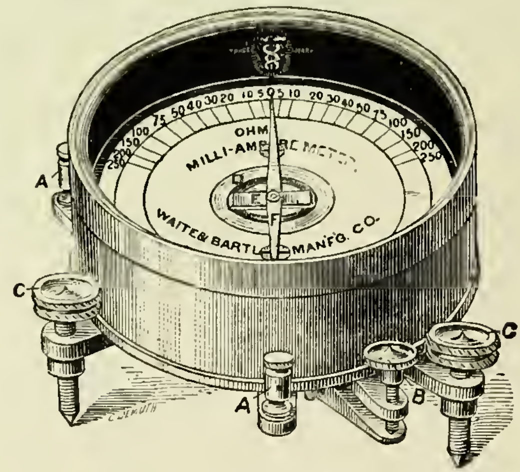


FIG. 1 —REPRESENTS A MILLIAMPERE-METER.

difference is dependent upon the individual, whether he is a good conductor or not, and this in turn seems to depend largely upon the constitution of the skin. A moist, thin skin conducts the current much more readily than does a dry, thick skin. In working one must keep his eye upon

the dial of the milliampere-meter, because the current sometimes lessens or increases after working a little time. If you have a pole-changer, never reverse it with the meter in the circuit, as it will spoil the meter.

The *coulomb* is the unite of quantity. It is the quantity of current which impelled by one volt would pass through one ohm in one second. Thus, it is apparent that if one were to apply a current of 10 ma. for one hundred seconds, a quantity of one coulomb of electricity would have been administered. The amount of one ampere current passing any point in a circuit during one hour is called an *ampere-hour.*

A *volt* is the unit of measure of electro-motive force which will circulate a current of electricity of one ampere through a resistance of one ohm; or, in other words, it is the unit of force or intensity of the current. The voltage or tension of a current is what gives it its penetrating force. A volt equals the electro-motive force of a freshly charged Daniell's cell. Some cells have a force of something over one volt, and others less than this, but very nearly all vary only a fractional part of a volt. The name is derived from Volta.

An *ohm* is the unit of resistance to the passage of electricity. It is equal to the resistance of a column of pure mercury, 1 square millimeter in section, and 106 centimeters long at the temperature of melting ice. The name is derived from the scientist, Ohm. Ohm's law is that the electro-motive force divided by the resistance is equal to the strength of the current.

Energy is the capacity for doing work, and is measurable by work units.

Electromotive force is the power that urges electricity forward, or causes it to move from one point to another; an electrified body tends to move from places of high to places of low potential; or, in other words, a tendency for electricity to seek an equilibrium. The greater the difference of potential the greater will be the electromotive force. The electromotive force is determined by the number of cells, not

their size. The electro-motive force of forty elements the size of a tumbler is no greater than from the same number the size of a thimble.

Quantity is the total amount of electricity passing through a circuit in a given time. The quantity of electricity generated depends upon the size of the elements.

Tension is that *quality* of electricity by which it overcomes resistance. Tension or intensity may be illustrated by the passage of water through a hose nozzle. If the size of the opening be diminished, the stream becomes dense; that is, there is a diminished quantity, but the force or intensity is increased. The tension of a battery depends upon the number of cells, the size of these elements having no influence upon it.

A *cell* or *generator* is that which produces an electric current. It is commonly a vessel containing a fluid, and within the fluid or solution a pair of elements, usually zinc and carbon. The electricity is generated wholly by the chemical action of the fluid upon the zinc, and, other things being equal, the quantity of electricity set in motion will be proportionate to the extent of zinc surface exposed to the fluid. The electricity flows from the plate most acted on through the liquid to the collecting or conducting plate (carbon), then through the connecting wires to the zinc again. Thus, as it will be seen, the zinc constitutes the positive plate *within* the cell, but the negative pole *outside* of the cell; the carbon forming the negative plate *within* the cell and positive pole *outside.* When two electrodes are placed in a liquid which acts more strongly upon one than the other, a difference in their electrical potential results; in other words, their equilibrium is disturbed. If, now, they be connected by metallic wires, the electricity flows from the higher to the lower, and the equilibrium is restored.

When a charge of electricity is constantly carried, and as constantly renewed, it constitutes a *current.* It must be understood that the term, "current," is a very misleading one, and is used in lieu of something better. It is misleading be-

cause it seems to imply that something like an intangible fluid is passing through a conductor, whereas in reality we do not know such to be the fact. The current or flow of the electricity is out from one terminal, and, when the circuit over which the current flows is closed, back to the other terminal.

By a *uniform* current is meant that the strength of the current remains the same during the entire sitting.

By an *increasing* current is meant that the current strength is gradually augmented without removing the electrodes. If the current is gradually increased, a much greater power can be borne than if it is suddenly let on in full force, with the first closure of the circuit. A current which may produce unbearable pain may be borne without discomfort if it is gradually increased from the minimum of current strength. When the electrode is on the head, cilio-spinal center, epigastric region, or pressed firmly down on the various motor points and nerve-plexuses, the current should be increasing.

Stabile current is the name given by Remark, when the electrodes are kept stationary during a sitting. *Labile*, when one or both electrodes are moved over the surface of the body. Labile applications are preferable to stabile in applying either faradism or galvanism to the muscles. Stabile are preferable to labile when the brain, spinal cord, or peripheral nerve-trunks are to be influenced.

Descending current is the name given it when the positive electrode is placed over the plexus or root of the nerves, and the negative at the extremities.

Ascending current, when the negative is placed over the roots of the nerves and the positive at their extremity or periphery.

The theory regarding the different effects produced by ascending and descending currents and the rules laid down for their use are now generally disregarded. It was based upon the physiological doctrine relating to the direction of the flow of nerve-impulse. It is now conceded by the best authorities that what was supposed to be the difference in the

effect of current direction is due to the differential action of the two poles. It is stated by some authorities that the descending current, the current flowing from centre to periphery, is more sedative in its effects; while the ascending current, the current flowing from periphery to centre, is more stimulating. We know that this difference in effect is produced by the two poles, and have no reason for thinking that the direction of current of itself has anything to do with the different effects produced. In other words, we pay particular attention to the location of the two poles in the application of electricity, and recognize the difference in action and effect of the positive and negative pole, but we do not recognize any particular difference in the direction in which the current flows, the differentiation in property attributed to the difference in the poles being referable partly to the phenomena of electrotonus and partly to a special influence exerted upon the circulation.

Superficial and *deep* or penetrating currents: The superficial signifies the application of a dry metallic electrode to the dry skin and superficial nerves; while the deep signifies the application of moist electrodes to the deep-seated tissues.

The *circuit* includes the fluid within the battery, the elements (the generating and collecting plates), the connecting wires and any intervening body with which the free ends of the wires may be in contact. The circuit is said to be "open" when the wires are separated, "closed" when they are in contact. They may be closed *directly*, as when the electrodes are brought together, or *indirectly*, as when any substance (the body, for instance) is placed between the electrodes.

Poles are the points where the electricity passes in and out, and are termed positive and negative poles. The *positive* pole is called the anode; the *negative* the cathode. The origin of the terms anode and cathode is sufficiently interesting to deserve mention. The flow of the electric current was likened to the course of the sun, arising at one place and descending at another. Thus the positive pole, which emits

the current, is the place where the current rises (Greek, ἀνα, up, and ὁδός, way)—anode; and the negative pole, which receives the current, is the place where the current disappears (Greek, κατα, down, and ὁδός, way)—kathode. The positive pole is the electrode by which the current enters the body. The negative pole is the electrode by which the current leaves the body. The current in passing from one electrode to another does not pass in a straight line between the two electrodes placed upon the surface of the body, for the whole of the connecting tissues between the electrodes help to provide a passage for the current, which spreads out from beneath the positive electrode, becoming less and less dense as it occupies a wider and wider sectional area of the conductor, and again grows dense as its lines of passage become more gathered together to reach the negative electrode.

Active and *inactive* pole: The active pole being that pole applied directly to the part or structure to be acted upon, while the inactive pole is that pole applied to some indifferent part of the body, having for its object only the completion of the circuit. Either the positive or negative pole may be the active pole, according to selection. It is a well-established principle in electro-therapeutics that the active pole should be as near the diseased tissue to be treated as possible, and that from the inactive or indifferent pole no therapeutical effect is expected—in fact, there is none except the mild counter-irritation produced by the hyperemia of the surface, which occurs under the electrode when strong currents are used.

A *conductor* is any material that will carry an electric current. Silver is the best conductor, and copper the next best. Copper is generally used, as it is cheaper than silver. Iron is a conductor, but not a good one.

An *insulator* or *non-conductor* is any material that will not ordinarily carry an electric current. There is, however, no such thing as an absolute insulator or non-conductor. We speak of glass, porcelain and rubber as being good insulators because they will not permit ordinary electric current to flow

through them. If the tension of a current be high enough it will penetrate any substance; but for currents used for medical work, rubber, porcelain, etc., will answer all practical purposes.

A *Farad* designates the capacity of a conductor to carry electricity, the name designating as much as will require one coulomb to charge it to one volt; in other words, one that will yield an electro-motive force of one volt by the passage of one ampere of current during one second.

The term *battery* should be employed when two or more cells are used together.

Appliances for the generation of electric currents are customarily called batteries, though an exception is made of the one producing frictional or static electricity, it being known as a *machine.*

Dielectrics are insulators through which electricity may act inductively.

Induction is the influence which an electrified substance exerts over a body placed near, but not in contact with it, in developing its neutral electricity, attracting the unlike kind to the proximal end, and repelling the like kind to the distal end.

Rheophores are wires or conducting cords connecting the electrodes with the battery. Conducting cords should be properly insulated. The insulation is for the purpose of preventing the two conducting cords coming together and thus making a short circuit, by which the current would suddenly be taken from the patient, and this with no little shock and pain if the application was made to a sensitive part; a similar shock would result upon the disengagement of the cords. Poor connections of connecting cords and electrodes produce frequent shocks by breaking the current.

A *rheostat*, or *current-controller*, is a contrivance for regulating the amount of flow of electricity. By its use the whole or any number of cells from the series may be used at once. The current can be regulated with perfect certainty,

and can be increased or diminished very gradually with absolutely no chance of producing shocks. In all delicate opera-

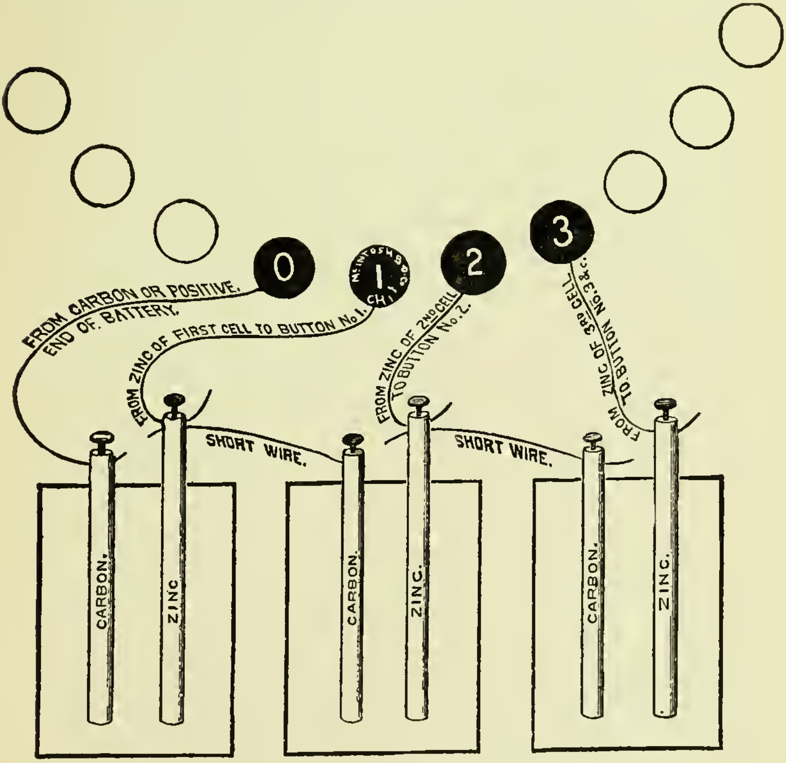


FIG. 2.—A DIAGRAM SHOWING UNDER SIDE OF SWITCH-BOARD AND METHOD OF MAKING CELL CONNECTIONS. (The Electro-Therapeutist.) Connecting the Cells: Place the cells in a cabinet, or on shelves, as desired, then connect zinc of first cell by means of a short wire, with the carbon of next, and so on until all are connected; that is, zinc to carbon; zinc to carbon; zinc to carbon, and so on until all are connected in continuous chain. Do not connect zinc of last cell to carbon of first. Connecting the Cells to the Switch-board: Connect wire No. 0, to carbon of first cell, wire No. 1, to zinc of first cell, and continue till all are connected. Then there will be two wires fastened to zincs of all cells but the last. Any number of cells can be used with this circle by skipping cells with the wires to buttons, thus putting 2, 3, or 5 cells to a button if desired. When connected thus the 0 wire will be positive, and 1, 2, 3, etc., will be negative. It will be remembered that the first cell receives *two* wires (No. 0, No. 1) from the switchboard.

tions it is necessary to use a rheostat, or current-controller, as the addition of cell by cell causes more pain, as each cell gives a little shock. Then, too, the current is not so readily or easily increased or reduced as with a controller. This instrument is placed in the circuit, usually attached to the battery, and by its aid the current can be applied so as to begin treatment with almost no perceptible current; at the same time prohibiting a too rapid increase in the amount of current when one or more cells are thrown into the circuit.

The *polarity-changer* affords a means of instantly changing the direction of the current; or, in other words, reversing the poles. The pole-changer not only changes the direction of the poles, but also produces the effect of a current-interrupter, while the change in polarity is being made.

A *selector*, or *cell-enumerator*, is an arrangement by which any desirable number of cells may be at once brought into the circuit.

Pole selection. Sometimes the poles of a battery get mixed, *i. e.*, the operator becomes uncertain as to which is the anode and which the kathode. Especially is this true after the battery has been taken apart and put together again. A simple method of pole-testing consists in placing both tips of the conducting cords in a glass of water (a saline solution is best); as soon as the current is turned on, bubbles of hydrogen gas quickly gather around the *negative* pole.

The *interrupter*, for the galvanic current, is usually contained in the handle of the electrode; a button is pressed upon, and this, by means of a spring, "makes" or "breaks" the contact.

An *automatic rheotome* is a clock-like instrument designed to produce regular interruptions of the galvanic current.

Resistance is whatever impedes the passage of a current through its circuit. The human body is a poor conductor. The resistance of the body is more than twice as great as that of the Atlantic cable. The resistance of the body from hand to hand, or from hand to foot, is about 5,000 ohms, while that

of a copper wire 1,000 feet long and one-tenth of an inch in diameter would be less than one ohm. The resistance is greater in young people than in old; it is greater in some individuals than in others, and even in the same individual it varies at different times. It is claimed that the resistance is somewhat greater, as a rule, in women than in men. The resistance is greater where the skin is thick and dry, and least where it is thin and moist. A scratch or an abrasion lessens the resistance, and this is the reason that when passing the electrode over the surface of the skin where there is a scratch or an abrasion the patient complains of its being so painful; a greater amount of electricity enters the body at that point. The mucous membranes conduct better than the skin. The mucous surfaces are good conductors by reason of their moisture. The junction of the skin and mucous membrane is in some localities much more sensitive to the current than are other parts of either. The vagina, uterus and rectum are tolerant to strong currents. The mouth and nasal passages are not so tolerant. Resistance is less when the skin is covered with perspiration; also by moistening the skin its conductivity is improved. The greatest resistance to the passage of electricity resides in the skin, which, next to the hair and nails, is the poorest conductor in the body, and after the skin is penetrated the soft moist tissues of the body, on account of the large percentage of water which they contain, and which is an excellent conductor, offer but slight resistance to the passage of the current. If the skin is moistened, or remains in contact with a moistened electrode, it soon loses its dryness, and becomes a much better conductor of electricity. At the same time the moisture will fill the pores, and through the sweat follicles find a more ready entrance into the tissues beneath; also, it is a fact that when electricity travels through a portion of the body, that portion which is situated under the electrode becomes reddened, and the capillaries are dilated as there is an increased flow of blood to the part; and in consequence of

this increased vascularity augmenting the conducting qualities of the tissues, and on account of the lessened resistance of the skin as it becomes more moist, the current becomes stronger as the application is continued, and often has to be reduced as the treatment proceeds. The resistance of the skin is still farther lessened by using a saline solution, prepared by putting a little common salt in the water with which the sponges are moistened, or a solution of common baking soda. The soda solution has the advantage of the salt solution, in that it does not corrode the electrodes, but has the disadvantage that greater care will have to be exercised in its use for if by accident it should come in contact with certain kinds of dress goods while applying the current the consequence is a stain in the cloth. It is estimated that by using either one of the solutions the resistance of the skin is lessened fifty per cent. A saturated solution of salt conducts 720 times better than fresh water. It has been estimated that the human body, owing to the salt that it contains, conducts nearly twenty times better than water. When the electrodes are applied to parts of the head covered with hair, the hair should be moistened, as dry hair is a non-conductor. The nearer the electrodes can be approached to each other, the less will be the resistance, as the amount of tissue is diminished. According to the researches of Ranke, when the current has once overcome the resistance of the cuticle and bones, it will spread almost equally through all the organs which are interposed between the two electrodes, the greatest effect being always produced near the electrodes.

Density is the amount of electricity on a given surface at any moment. When the current is concentrated, it is said to be dense, and it exerts more action than when spread out or diffused over a large area. The density of the electricity will be greatest at those points where it enters and leaves the body, and smaller at any intermediate portion of the same. A current of the same power possesses more density if conveyed

by a small electrode than if transmitted by a conductor with a large surface.

Polarization is due to the accumulation of bubbles of hydrogen upon the carbon, and of oxygen upon the zinc elements. These bubbles of oxygen and hydrogen set up a counter-current in a cell, and this current flowing in an opposite direction to that of the battery current has a tendency to weaken the latter, and eventually may neutralize it. Then we say that the battery is "run down" or "weakened." Of course, after the battery has been at rest, the current recovers to a degree, but never regains its original strength, and disappears again after a certain amount of work.

Potential is the electrical level of a body above or below that of the earth, which is taken as the standard of comparison and assumed to be zero. If the electrical level of an object is above that of the earth, it is said to have *positive potential;* if it is below that of the earth it has *negative potential*, and electricity flows from the earth to the object.

Electrotonos has reference to the peculiar modification of irritability which nerves and muscles undergo when acted upon by a galvanic current. When, by means of electrodes, the galvanic current is applied along the course of the nerve, that portion between, as well as a limited portion outside the poles, are said to be in an electrotonic state; that is, the natural nerve-current is modified. There are two modifications of the electrotonic condition termed, respectively, *anelectrotonos* and *catelectrotonos.* Anelectrotonos is a condition of diminished irritability taking place at and near the positive pole or anode; while catelectrotonos is a condition of increased irritability taking place at or near the negative pole or cathode. Somewhere between the poles, there is a part called the neutral point. A nerve in a catelectrotonic state has its irritability increased, while a nerve in an anelectrotonic state has its irritability decreased; hence the reason for applying the negative to increase irritability, as in some forms of paralysis, and the positive to allay pain.

The contractions resulting from sudden reversals of polarity by means of a commutator are known as *voltaic alternatives*, and are much more powerful than those resulting from simple "makes" and "breakes," and are especially powerful in exciting muscular contraction. Frequent repetition of these changes of polarity is often the only manner in which contractions can still be produced in markedly atrophic muscles with very much diminished irritability.

By the term *catalysis* is understood that process of disintegration and absorption which takes place when electrodes are placed on the surface; that is, the current's power of affecting the actions of the molecules of the tissues, of dilating blood and lymph vessels, and restoring the tone of nerves.

An *electrolyte* is a substance that does not conduct electricity without undergoing decomposition. Faraday discovered one peculiarity without exception—that substances which were bad conductors in the solid state, but did conduct in a melted condition, only did so by suffering decomposition.

Electrolysis is derived from the Greek words ἤλεκτρον, electricity, and γνω, to disengage, and signifies that process by which a compound substance is decomposed by electricity, a chemical decomposition. *Electrolysis can be obtained only by means of the galvanic current*, and depends chiefly on the intensity and duration of the current. This action of the galvanic current upon various compounds is due to the polar effect of such current, which must be unbroken or uninterrupted for a certain considerable length of time, in order that there may be demonstrated any decided change going on in the electrolyte.

Electrolysis is the conversion of galvanic electricity into chemical action, and the cauterization is brought about by the liberated acids or alkalies. Electrolysis applied with a mild current will cause absorption only—a galvanic, chemical absorption—while the strong current will burn, cauterize, or even destroy tissues. Therefore, the operator must know what effect he wishes to produce, and graduate the strength

of his current accordingly. The action of the poles is very different in electrolysis, and each has its own function.

When two needles attached to the two poles of a galvanic battery are introduced into animal tissue, the negative pole attracts the alkalies, hydrogen, and the base of the salt, dissolves blood, coagulates albumen and causes absorption. At the same time, bubbles of gas may be seen welling up along side of the needle about the negative pole. These are bubbles of hydrogen caused by the potassium and sodium set free, uniting with the oxygen and decomposing the water in the tissues. The same chemical action produces caustic soda and potash, and these destroy the tissues just as they would in the ordinary way.

The positive pole attracts the acids and the oxygen from the tissues and coagulates blood. The tissues become oxidized and are more or less charred, just as after cauterization with a strong acid. At the same time the needle, if a steel one, is oxidized. If, however, the positive pole is to be used, a platinum or gold needle will have to be employed. The negative pole is more often used, as the scar from it is softer and more pliable than is that caused by the positive pole. From this it is evident, that for the immediate destruction of tumors and for treatment of strictures the negative pole should be used. This operation of electrolysis on certain forms of tumors is safer against their return and also much less disagreeable to the patient than an operation with the knife. There is no one branch or principle in relation to medicine and surgery that is more clean, exact and scientific than that of electrolysis of the living tissues, when intelligently and properly applied.

Electrolysis is of special value in the treatment of strictures, fibromata and other small tumors, moles, warts, lupus, hypertrichosis (superfluous hairs), and nævi of all sorts; it is also one of the best means for removing powder stains.

In employing electrolysis, it is of vital importance to distinguish the poles, and as we cannot trust to the marks of the

instrument-maker we must always ascertain which is the positive and which the negative pole. When the needle of the positive pole is stuck into a piece of meat it adheres firmly to it, while the needle of the negative pole sticks loosely in the meat, and can be easily removed; or, again, if the tips of the conducting cords, separated one or two inches, are laid on a piece of moistened litmus paper, that around the negative tip will turn blue while that at the positive will turn red.

The simplest test, however, and the one most quickly made, is to place the tips of the conducting cords into a vessel containing water, or better still, a saline solution—the current being turned on previously, bubbles of gas will gather around both tips, but much more quickly around the negative; also the tip of the positive cord will be blackened.

When any substance is decomposed by electricity, the products resulting from such decomposition are called *ions;* those ions which appear at the anode or positive pole are called "*anions*," and those which appear at the kathode or negative pole, "*kathions.*" The anions are electro-negative and are repelled by the negative pole, because they are the same potential as that pole. The kathions are electro-positive, and being repelled by the positive pole, whose potential is the same, they are drawn to the negative pole in accordance with the well-known law that "unlike poles attract, like poles repel."

By *electrical osmosis* is understood the introduction or passage of fluid or crystaloids in solution through a tissue (skin or mucous membranes) or porous septum, by the agency of a continuous electrical current. This process may be either a physical or an electrolytical one, but is chiefly the latter.

Electrical osmosis includes *cataphoresis* and *anaphoresis*, and is the one or the other, according as the diffusion is from the cathode or from the anode, respectively. In this process some medicines are carried more rapidly than others—the

alkalies more rapidly than the acids, some alkalies more rapidly than others, and some acids more quickly than others.

Cataphoresis, or anaphoresis, as has been said, is chiefly an electrolytic process. The medicamental (the drugs to be introduced into the circulation for medication of local lesions, or the drugs employed to produce anæsthesia) is broken up into its elements, some of them going towards the negative pole and some towards the positive, according as they are electro-negative or electro-positive.

Chemical bodies are classified in this science as either electro-positive or electro-negative. The alkalies are electro-positive and the acids are electro-negative elements. The following are a few of the many elements that are electro-positive and electro-negative :

Electro-positive solutions: Hydrogen, potassium, sodium, silver, copper, tin, nickel, zinc, lead, magnesium, calcium, ichthyol, ammonium, gelsemium, jaborandi, iodoform, cocaine; these have a strong affinity for the negative pole. As a broad statement it may be said that nearly all of the metals are electro-positive.

Electro-negative solutions: Oxygen, chlorine, bromine, nitrogen, sulphur, fluorine, phosphorus, carbon, iodine; these have a strong affinity for the positive pole.

Binary compounds (medicaments composed of two elements) are composed of a base and an acid, or that which takes the place of an acid. The acid, or that which takes its place, is an electro-negative element, while all the bases are electro-positive.

In cocaine hydrochlor., the cocaine is the base, and as all bases in compounds are electro-positive, the cocaine would be applied to the positive pole, which will repel it and transfer it to the negative pole, for which it has an affinity, while in potassium iodide (the iodin in potassium iodide takes the place of an acid) the iodin represents the acid, and as all acids in compounds are electro-negative, the potassium iodide

would be applied to the negative pole, which will repel it and transfer it to the positive pole, for which it has an affinity.*

As a rule, the following law is trustworthy: The base of a salt will be introduced into the tissues by the anode, while the cathode must be employed to cause osmosis of the radical. This shows that there is a law of polarity (bodies of like polarity repel, those of unlike polarity attract) that must be observed in cataphoresis; also a chemical law that must not be forgotten.

The volume of current used in cataphoresis varies from ten to twenty ma. After a ten minutes' seance, or if forty ma. are used, the acids of the body accumulate at the anelectrotonic zone to such an extent that the medicine is partially destroyed, and a similar effect occurs at the negative pole; therefore, a mild current, and of not more than ten minutes' duration, should be used.

Electrodes are the direct means of applying the electricity to the body. The size of the electrodes is of importance in treatment, the density of the current being greater at the point of contact on the surface of the body with a small than with a large electrode; therefore, if we should desire to concentrate the current upon a certain organ or part, the small electrode should be applied to or over this organ or part, and a large one at some indifferent part of the body.

The electrode whose special action is desired—termed the *active* electrode—is placed in the nearest possible relation to

*This is easily proven by the following test: Take a piece of blotting paper, moisten well with water, and place a small spot of pure tr of iodine at about the center, next close the galvanic current by placing the tip of the cord from the negative pole near the spot, and the positive tip on the other side and a little farther away from the spot. In a few moments (if the current be sufficiently strong), you will observe the spot of iodine to be gradually, clearly and boldly creeping and receding away from the negative pole and collecting around and under the tip from the positive pole, and, indeed, if the current be continued for a sufficient length of time, the entire spot will be neatly and cleanly transferred from its original position, proving, beyond doubt, that the element iodine has an electro-affinity for the positive and is repelled by the negative, respectively.

the tissue to be affected; while the other electrode—termed the *indifferent* electrode—is placed at some remote part of the body. The indifferent electrode should be constructed of large dimensions, in order to spread the current strength employed over a large area.* The effect of the active pole is in no way reduced thereby, as the density of the current is not appreciably diminished in applications by the polar method, whether the electrode is large or small.

If the concentration of an electric current in the anterior half of the body is desired, the electrode must be proportioned in size to the distance of the point at which it is desired to concentrate the current from the pole designed to be the active one. Two large electrodes of equal size, placed upon opposite sides of the body, will concentrate the current at the center of the body, or midway between the two electrodes. If one electrode is made smaller than the other, the point of concentration will be proportionately nearer the small electrode.

The electrodes must be in direct contact with the skin or other tissues to be treated, as the current will not pass through the clothing. Always press the electrodes firmly and evenly against the part which it touches; this renders the current employed an even one to the patient, and assists in its conduction.

Do not break connections while the current is on, as it causes a painful sensation or shock to the patient. When employing strong currents there is nothing so disagreeable to the patient as the sudden and repeated shocks which occur when the electrodes are handled carelessly. Avoid all unnecessary irritation. Do not make any interruptions or changes of polarity, if not absolutely required. Always endeavor to apply one of the poles to the part which is diseased. Never under any circumstances lay an electrode or anything

* It is best made of thin sheet copper, 4 x 6 inches, with a binding-post riveted or soldered on to it. Copper is far better than zinc, for the zinc electrodes soon become brittle and the binding post is readily broken off.

else that is metal upon your switchboard, for in this way it is very easy to short-circuit your battery.

The electrodes may be covered with canton flannel, or absorbent cotton. The objection to sponges is that they become filthy and dirty. Too often physicians become careless in their use, and will continue to use upon the most delicate and sensitive patients dirty sponges saturated with perspiration absorbed from many individuals; sponges which for one moment they would not tolerate upon their own person. The advantage of absorbent cotton is that it can be changed frequently, little expense being incurred. The flannel covers can be removed and washed. The cotton or flannel can be held in position by slipping a rubber band over the stock of the electrode. If it is the desire to act principally upon the skin, the electrode should be used dry, for a dry electrode will act more on the skin and less on the muscles, while moistened electrodes less on the skin and more on the muscles. If a limb is to be subjected to the electric influence, it may be immersed in water in which is one electrode, the other being placed on some portion of the body to complete the circuit; or two dishes of water may be used, one for each limb, each containing an electrode.

Seance, or *sitting*, has reference to the giving of a single electrical treatment. The time required to give a treatment will depend upon the part to be treated, the nature of the case and the form of electricity employed—varying from three to thirty minutes. When electricity is applied to the head, neck, or localized to spinal nerve tracts the length of the sitting should be short—three to eight minutes; when applied to the abdominal or pelvic organs, or to the system in general, the sitting will vary from ten to thirty minutes. As a general rule, however, the duration of each sitting should be about ten minutes; but the time may be shortened or lengthened as may seem advisable in each particular case. The galvanic treatments are, as a rule, the shortest, the faradic a

little longer, and when giving static electricity the sitting is usually longer than when using the other currents.

The questions are often asked, how frequently should an electrical treatment be given? and, what period of time should constitute an electrical course? In regard to the first question, the frequency of the applications will depend upon the nature and severity of the case. In some cases the treatment will have to be given every day (nothing will be gained by treating the case more than once daily) until relief has been obtained, or until there are decided indications of improvement. This will only have to be resorted to in rare instances. Usually the treatment should be given every other day or every third day, for a period of from twenty to thirty days, and then once a week while the course lasts. In regard to the second question, as to the length of the electrical course, it also will vary in different cases. Generally speaking, however, it is necessary to use electricity for a month or six weeks. Occasionally one or two applications of electricity are sufficient to cure a patient; as in hysterical aphonia, muscular rheumatism, neuralgia, and amenorrhœa.

A good rule to follow is that as soon as the patient is completely relieved of the trouble for which he sought advice, discontinue the treatment and wait for developments; for in some instances to continue the treatment after the patient is better may even prove harmful. In chronic cases that require long-continued electrical treatment it is better, after using it for two or three months, to discontinue the treatment for an equal length of time and then later to recommence it.

The *current strength* refers to the quantity of electricity that the patient is receiving. As regards the exact strength of current, no absolute rule can be given for every case, but in the various affections described later in which electricity is applied only an approximate "dose," for the guidance of the student and practitioner is given; this has to be discovered by individual experience. One point, that it is well

worth remembering, is that it is always better to give too small a dose than too large a one.

The strength of the current must be graduated according to the sensation of the patient. It is better to commence with a mild current and increase the strength gradually. The amount of electricity to be given in any case will vary according to the age and condition of the patient, and the locality to which the current is applied. Some patients can stand much more than others, and, again, certain parts of the body are more sensitive to the action of the current than others.

It may be laid down as a general principle that a feeble current used for a short time produces the greatest therapeutical effect; that a powerful current almost always does harm instead of good, and more especially so when it is applied for a considerable length of time, and that but little benefit is likely to follow torture, and that no needless pain should be inflicted upon the patient.

The majority of new patients imagine that as soon as electricity is mentioned that it is connected with shocks and pain. Relieve their minds at once on that score, and convince them by demonstration that the current is entirely under your control, thereby winning their confidence. Electricity given in such a way as to frighten or excite a patient, or hurt him, does more harm than good. A current so strong or applied so long as to produce soreness of muscles, cramps, or great fatigue does more harm than good. Too weak a current can never do harm, but too strong a current is capable of producing irreparable mischief.

The popular idea seems to be that if a little electricity will do good, more must be better. The patient is anxious for recovery; the doctor wishes to make a favorable impression, and frequently yields to the request "to put it on stronger," often to the damage of the case. A good rule to follow in making electrical applications is to always begin the electrical treatment with the current at zero, thus lessening the danger

of a sudden shock to the patient, and before removing the electrodes or breaking the current reduce the current to zero; this avoids the danger of short-circuiting the battery.

If a patient complains of feeling dizzy or faint during a treatment, it is indicative that the current is too strong and should be reduced; but generally, under such circumstances, it is better to defer further treatment until another day. It occasionally happens that patients do not bear electricity well; after an electrical treatment they may be subject to headache, or are nervous and sleepless the following night. In such cases electricity will have to be employed very carefully. In many of these cases, after a few applications of a mild current, these nervous symptoms fail to make their appearance, and the patient may enter upon the regular electrical course; while in other cases the electrical treatment will have to be abandoned entirely. Mild currents frequently repeated are preferable to strong currents at long intervals. Mild currents *only* should be applied to sensitive parts.

General electrization consists in passing the current through the main part of the system, which may be accomplished by placing the feet on a moist copper plate connected with one pole, the other electrode upon the head, neck or hand.

Localized electrization consists in limiting the current as much as possible to certain organs or tissues, such as a limb, muscle or nerve. The smaller the electrodes and the nearer they are together, the less diffusion of the current there will be.

The term *electrization* includes galvanization, faradization and franklinization.

In a conductor charged to a high potential, the electricity escapes from any sharp point or edges. When the action is unaccompanied by noise or light, it is called a *silent discharge.*

When the discharge takes place from a blunt conductor there is a luminous appearance which assumes a form somewhat resembling a brush, or, more accurately speaking, a

broom. This has been termed the *brush discharge.* The brush is generally accompanied by a crackling or hissing sound, or even a musical note.

By the term *convective* discharge is meant what is commonly known as the static spray or breeze. It is in reality a succession of infinitesimal sparks, as obtained from a powerful static machine, which passes into a continuous stream between the two discharging rods or the insulated patient and the administering electrode; while a *disruptive discharge* has reference to the sparks.

Magnet, from Magnesia, a country in Thessaly, where it was first discovered, consists of a reddish-brown or gray ore found in iron mines throughout the world; it is also called loadstone; these are termed natural magnets. Artificial magnets are those in which the peculiar properties of magnetism are induced artificially. Artificial magnets are generally in the form of a bar or U; the latter called horseshoe magnets. A horseshoe magnet is three or four times as powerful as a bar magnet. Magnetism, the peculiar property belonging to magnets, may be defined as electricity in rotary or whirling motion; that is, magnetism and electricity are but different properties of the same force, or different manifestations of the same force.

Magnets are often of service in forming a diagnosis, indicating the presence and position of needles or small pieces of steel or iron in the tissues, and are frequently a great aid in the removal of foreign bodies. The electro-magnet is the form now usually used for such purposes. Magnets in the treatment of disease are little used, static electricity having almost entirely superseded them.

GENERAL REMARKS.

The time has come when a medical education cannot be said to be complete without a knowledge of the working principles of electro-therapeutics. The two essentials to suc-

cess in electro-therapeutic practice are, first, a thorough knowledge of the subject, and, second, the proper appliances to work with. Let no one complain of his failures until he has the knowledge and a proper electro-therapeutic outfit. It is self-evident that familiarity with electric current action upon and within the living tissues is a basic need to the physician who prescribes an electric current therapeutically.

Skill and the requisite knowledge in this special branch comes only by close observation, hard study and much experience. Every physician before undertaking to use electricity should study and know the difference between the various currents; between quantity and intensity; know the effect of one pole from that of the other or he is likely to do more harm than good.

Notwithstanding the undoubted utility of electricity as a medicinal agent, there still remains a large class of practitioners who rarely employ it, and are apparently content to remain in almost complete ignorance of the subject. This apathy or lack of confidence in electricity is usually the result of an absence or insufficient knowledge of the subject. It is no exaggeration to say that a not insignificant number of practitioners make use of the different kinds of electrical currents indiscriminately and without sufficient regard for the laws of electro-therapeutics which should govern their employment; or they employ it because it is said to be good for such and such diseases; these are naturally disappointed in the results, and look upon it with suspicion. The most gratifying feature is that this class of physicians is rapidly growing less, and that the more familiar physicians become with the manifestation of electric energy, the more do they recognize its adaptations to the requirements of disordered physiological conditions.

Too often it is the case that patients are recklessly and indiscriminately recommended to purchase batteries, and have the application made by themselves or their friends. Benefit may sometimes follow this blind procedure, but as a rule

more harm will be done than good; for electricity, like all powerful drugs, is a dangerous remedy in the hands of the ignorant, and like every remedy, it has its specific place. If there is any one therapeutical process in the whole range of practical medicine, that more than another defeats its own legitimate end, through careless and ill-directed or ignorant applications, it is *electricity*.

Electricity is one of the most useful and most abused of all the remedies at the command of the modern physician. It is one of the most useful because it is applicable in a large class of troubles, and will often reach conditions that drugs will not touch. It is one of the most abused because it has been a proficient field for charlatans and quacks. If there is an occasional quack using electricity, are there not many of them using medicine? If there are electric belts and corsets, magnetic in-soles and rings, are there not also liver pads, medicated plasters, and patent medicines that are worthless.

Physicians must disabuse their minds of the idea that all there is in electricity is simply to apply a galvanic or faradic current to the most convenient portion of the patient's anatomy; they must by study and research learn to discriminate which of the various currents to select, and the various methods of applying the same, together with the duration and frequency of the applications; for electro-therapeutics is no longer the careless haphazard practice it used to be, but has developed to the state of an exact science, having clearly marked indications for application to different diseases and requiring exact discrimination.

The science of electricity, which has become such an important factor in our every-day life within the past ten years, is erroneously alluded to as a new science. While the practical application of electricity has recently come in vogue, it is by no means a new subject, and can scarcely be called "in its infancy," when it is taken into consideration that the first work on the subject was published in 1490, and, therefore, was "in its infancy" before America was discovered. But it

was not until 1600 that electricity was recognized as a distinct branch of science. It is, therefore, well to deal with it as a distinct branch of physics, rather than to still imagine all the researches regarding this mysterious power to be in an experimental state.

The physiological study of the action of electric currents shows that at first they stimulate nutrition, but if employed too long a period or in too great strength they devitalize and destroy the tissues upon which they act; also that if an electric current is applied to a healthy nerve, the normal nerve-current is perverted or abolished, but if applied to a nerve whose normal nerve-current is perverted or abolished it will correct or restore it. On this point Dr. A. D. Rockwell says: "When an irritable nerve is brought under the influence of a rapidly interrupted galvanic current, the nerve-current gradually diminishes in strength until it is finally destroyed. Nothing is better established in physiology than the above fact; and yet, paradoxical as it may seem, when a nerve, through injury or disease, has quite lost its irritability to the faradic current, it frequently regains it after several applications of the interrupted galvanic current."

The action of electricity on voluntary and involuntary muscles is quite different. In *voluntary* muscles, contractions are produced immediately upon applying the current and at the end of the treatment they immediately return to their normal condition; while in *involuntary* muscular fibers, as in the intestines, stomach, œsophagus, etc., contractions are immediately started upon application of the current, but the movement, when once induced, will continue for a considerable time after the cessation of the treatment.

Peripheral faradic or static stimulation excites strong centripetal nerve impulses, which, if not inhibited, return as motor impulses, in either case causing a profound reaction in the system. The physiological responses in nerve and muscle, resulting from the passage of a constant current through them under certain conditions, have become to the neurologist an

indispensable requisite for determining the functional and structural condition of nerves and muscles, when for any reason their integrity is called in question. Electric diagnosis does not depend wholly upon the use of the constant current, but taken in connection with induced applications it elicits information regarding the action and state of nutrition of nerves and muscles with a certainty and accuracy that contributes much to both the diagnosis and prognosis of disorders affecting these structures.

The galvanic current will produce contraction of muscles only when the circuit is "closed," never when "opened" unless the nerve is diseased, when the contraction may also occur when the circuit is "opened."

A muscle will contract under the influence of electricity in two ways: (1) When the electrode is applied along the course of the motor nerve or to its motor point—point of entrance of a motor nerve into the muscle to which it is distributed;* (2) when applied directly to the muscle itself. When the current is applied to the motor nerve—placing one pole over the nerve, the other over the muscle or muscles supplied by its branches—all the muscles controlled by that nerve will contract uniformly and the contractions will be stronger than when the current is applied to the muscle itself. This fact is utilized for electric diagnosis in determining the state of the nerves and muscles supplied by it, as well as for treatment when the muscle group supplied by any nerve is impaired through or by reason of fault in its nerve supply. When the current is applied to the muscle an electrode is placed at either end of the muscle, when through excitation of the muscular and intra-muscular nerve fibers contractions more or less powerful take place; by this method we obtain contractions only of that muscle or portion of muscle included between two poles.

* The most prominent motor point on the surface of the body is the sixth cervical vertebra. When one electrode is located at this motor point, and the other at any other part of the body, electrical excitation will ensue.

So long as muscles preserve electric contractility, they can be preserved from complete fatty degeneration by the judicions use of electricity. When, however, muscles cannot be made to contract by the faradic, galvanic or franklinic current, it is useless to treat them with electricity, but even if a few slight contractions can be produced it will indicate a favorable result under a careful and persistent treatment.

As a rule, when you wish to obtain the sedative effects of electricity you will use the galvanic current, using the positive pole over the irritated parts, especially in the treatment of nervous diseases. When it is the stimulating effect that is wanted, as in the treatment of paralyzed muscles, use the faradic current; but, however, to excite contractions in a degenerating muscle the interrupted galvanic current is vastly superior to the faradic.

When employing the galvanic current, applying the positive electrode over the abdominal sympathetic ganglia and the negative electrode over the extremeties increases the circulation; applying the negative electrode over the abdominal sympathetic ganglia and the positive electrode over the extremities decreases the circulation. If the faradic current is employed it will make little difference which electrode is placed over the abdomen, which is placed over the extremities.

A strong galvanic current passed through the small intestines from the six lower dorsal vertebræ (the origin of the splanchic nerves) will diminish the peristaltic movements of the intestines (consequently causing constipation of the bowels); while a weak galvanic current will act as a tonic, and the peristaltic movements will be increased. In using galvanism through the intestines the electrodes should be widely separated, lest painful contractions occur.

When a strong current is applied to the pneumogastric nerve, it increases its inhibitory power and thus slows the heart's action, and, if strong enough, stops it.

When a powerful galvanic current is applied a long time,

it will produce inflammation and sloughing of the skin; while with the faradic, even though a very powerful current is applied, it never produces nutritional disturbance.

Electricity affects a tissue in several ways: (1) By its effect on the vaso-motor nerves, changing the activity of the circulation, increasing or decreasing the arterial blood-supply and removing venous stasis; (2) by producing contractions of muscular fibers to be followed by their relaxation (this motion mechanically increases the circulation); (3) by breaking down partially organized exudations and plastic deposits which bind together the walls of cellular and inter-muscular spaces and consequently interfere with the physiological action of the part and obstruct its circulation, and possibly that of neighboring tissues; (4) by the destruction of such products of inflammation as granulations, polypoid growths, vascular tumors, and of morbid growths in general.

The electric current is a most subtle agent which may be made to serve many purposes, and which possesses numerous, greatly varying, and even antagonistic properties, which can be developed at will by the accessory apparatus and the method of application. So wide is the range of adaptability of electricity to the treatment of disease that it must become the common property of every physician, no matter whether his work is general or special in its nature, and, such being the case, instruction in electro-therapeutics should have a place in every medical college curriculum.

If those physicians who are connected with asylums and sanitariums would make a special study of the physiological action of electricity, they would become acquainted with a remedy of great value; and if they would but learn how best to employ it, they would produce results which in no case would be injurious, in a few cases would be brilliant, and in almost every case would benefit the patient in some way.

In the use of electricity some physicians are more successful than others. This depends in part upon the judgment with which suitable cases are selected for treatment, but

chiefly upon the details given to treatment; success depends more upon this than upon the form of electricity employed. We must learn to recognize not only the diseases most amenable to electric treatment, but also the method of application best adapted to each case; we must also study accurately the effects of different doses of the current, for, as Althaus points out, there is reason to believe that small doses have contrary effects to those of large doses of the same agent.

Electricity is like medicine, in that certain definite results will occur if the proper dose and mode of administration is followed; and, like medicine, a certain dose may be sufficient for one person and secure good results, while for a second person a much larger or smaller dose must be used. As much, therefore, depends upon the proper application of electricity, in quantity and quality, to secure good results, as in medicine does the dose to secure the proper action. Like all other remedial agents, electricity has its place and power; it should be used according to special indications and well-defined laws.

ELECTRIC DIAGNOSIS.

Reflex action in voluntary muscles depends upon:

1. The sensory nerve which conveys the irritation to the multipolar cells in the anterior horns of the spinal cord.

2. Upon the multipolar cells which receive and perceive the irritation, and originate a motor impulse.

3. Upon a motor nerve which conveys this motor impulse from the multipolar cells in the anterior horn of the muscle. This constitutes what is known as a "reflex arc."

If there is a diseased condition of the sensory nerve, so that the irritation does not reach the multipolar cell in the anterior horn, there will be loss of reflex action in the voluntary muscle supplied by that nerve.

If there is disease in the multipolar cell of the anterior horn, so that it cannot perceive the irritation or originate a motor impulse, there will be a loss of reflex action in the

voluntary muscles supplied by nerves from this point, and, in addition to loss of reflex action, almost complete loss of voluntary motion; and also atrophy of the muscles.

If there is a diseased condition of the motor nerve connecting the anterior horn with the muscle, there will be loss of reflex action, complete paralysis of voluntary motion, and atrophy of muscles supplied by this nerve.

In the normal state, nerve-fibers are stimulated by either the faradic or galvanic current: the stimulation of the motor nerves being shown in the contraction of muscles supplied by them, that of the sensory nerves by the sensation that is caused. This electric irritability is changed by disease, being lowered in proportion as the nutrition of the nerve-fibers is impaired; conseqently it requires a stronger current of each kind to excite the nerves and cause contractions in the muscles which they supply.

By the end of the second week the faradic and galvanic irritability of the nerve will be entirely abolished. In the muscle the reaction to faradism runs the same course as in the nerve; that is, there is a gradual diminution and finally a loss of faradic excitability. To galvanism, on the other hand, there is at first a progressive lowering of excitability, but by the end of the second week this is replaced by an increase of excitability, so that very weak currents, when the current is "made" or "broken" (that is, when the current is interrupted), may excite contraction of the muscles. This contraction is due *not* to the stimulation of the nerve, but to the stimulation of the protoplasm of the muscular fibers themselves; this phenomenon is known as "reaction of degeneration," and occurs when the nerves are separated partially or completely from their motor (trophic) nerve cells, and if no such separation exists, it indicates either an acute degenerative change in those nerve-cells or in the nerve-fibers; all involuntary movements are then impossible.

The term "reaction of degeneration" signifies that the muscle has lost its faradic irritability, and that the nature of

the response which the degenerate muscle makes to the continuous current differs from that exhibited by a healthy muscle. In health, when the galvanic current is applied to a muscle, the resulting contraction is quick, instantaneous; but when the reaction of degeneration is present, the contraction is slow and sluggish, thus differing markedly from the very rapid, lightning-like contraction given by a normal, healthy muscle.

In health the first contraction to occur on gradually increasing the strength of the current is at the *negative* pole when the circuit is closed, and a stronger current is required before closure-contraction occurs at the positive pole. But in diseased condition, the closure-contraction may occur at the positive pole as readily as at the negative, or more readily, and contractions when the circuit is broken occur far more readily than in the normal state. After four to six weeks this galvanic hyper-irritability begins to diminish, and the diminution is progressive until at last it becomes stationary; or after several weeks or months finally disappears. Electric irritability will remain absent unless union of the divided nerves takes place. In that case the muscular irritability to both currents returns gradually, the slow, tardy contraction gives place to the quick, lightning-like ones, and the normal formula of contraction for nerves and muscles is re-established.

In testing nerves and muscles electrically, there are two points that should be kept in mind, namely: 1. If the faradic current fails to produce muscular contraction, we know positively that the motor cells of the anterior horns of the spinal segments which control the paralyzed muscles are impaired, or that the nerve itself has been severed from its connection with the spinal cord, or is undergoing degeneration. 2. If the formulæ obtained by the galvanic current are normal, all questions regarding the existence of the degenerative changes in the nerve, or muscle-plates, can be excluded; but when the normal order is altered, degenerative changes in the nerve or motor cells of the spinal cord are present.

In making an electrical examination for diagnostic pur-

poses, the indifferent electrode should be of large size, in order to overcome the skin resistance, and should be placed over a distant part of the body, as upon the sternum, or the sacrum, or the nape of the neck. Erb recommends the sternum as the best position for the indifferent electrode, because it is both symmetrical in position and is also further removed from the spinal nerve-trunks than any part of the surface of the back. The exciting electrode must be of small size, for the sake of localizing the current to the particular nerve or muscle to be tested. For localizing the current in the smaller muscles, such as those of the face or hands, small conical electrodes should be used.

The electrodes should be covered with chamois skin or sponge, and thoroughly moistened with a saline or soda solution. Care must be taken that the electrodes are in good contact with the skin; also that the exciting electrode is applied with uniform pressure. The exciting electrode should have a key arranged conveniently in the handle for closing and opening the circuit. This electrode is termed an interrupting electrode.

When the faradic current is employed, it is of little consequence which pole is used, as the reaction of nerve and muscle is the same in quality for both poles; the secondary current, however, acts with greater intensity, and is for this reason usually employed; but when using the galvanic current, the selection of the pole to which the testing electrode is attached is of the greatest importance. In the galvanic current the current always passes from the positive to the negative pole; hence, when the positive pole is placed on the breast or neck and the other on the muscle to be treated, we have a *descending* current, and an *ascending* current when the negative is placed on the head or neck and the positive on the muscle.

The faradic current is valuable diagnostically for determining the existence and increase or decrease of pathological excitability, in differentiating between central and peripheral

lesions, and in the detection of simulation. To test the normal reactions of nerves and muscles, the galvanic current is the one used exclusively.

Electricity may be used to distinguish between apparent and real death. The thought of being buried alive is probably the most repulsive one which may present itself to the human mind. There is no doubt that numbers of persons have been buried alive, more especially during epidemics and after great battles. The signs of death commonly relied upon, such as holding a looking-glass to the mouth to detect moisture, dropping melted sealing-wax on the skin to cause reflex movements, cessation of the heart's action and of respiration, stiffening of the muscles (rigor mortis), the dull cornea, the dilated pupil, non-transparency of the fingers to lamp-light, etc., are occasionally of doubtful value, since all have been present in cases of trance.

In the faradic current we have an agent which will tell us positively within two or three hours, or at most six hours, whether life is or is not present. When the faradic contractility is gone, we may say with certainty that death has taken place. No disease, nor any kind of asphyxia or poisoning, will, during life, abolish the faradic contractility of all the muscles of the body. In real death the power of the faradic current to excite muscular contraction ceases within one-half to three hours; a few instances, however, are on record where it has remained even five or six hours. It disappears more rapidly after death from chronic than from acute diseases. An exception to this rule is met with in cases dying from cholera, where it has been found to be gone in thirty minutes after life has been extinct. The electro-muscular contractility remains longer in well-nourished than in wasted bodies. M. Crimotel, of Paris, says that in new-born infants muscular contractility, under the influence of the faradic current, continues fifty to sixty minutes after the heart has ceased to beat. When they never have exhibited

the signs of life, the faradic test shows whether life is really extinct.

In apparent death (trance) the power of the faradic current to excite muscular contractions is never lost. Professor Rosenthal cites a case where the patient had been apparently dead for thirty-two hours; on applying the faradic current all the muscles responded to the stimulus; whereupon he pronounced the patient not dead, but merely in a trance. The subsequent history of the case proved this diagnosis correct, for within twelve hours afterward she spontaneously awoke, recovered, and was alive two years afterward.

As a résumé of the above subject, we would give the following precept:

The loss of preservation of the farado-muscular excitability may be used for rendering perfectly certain the diagnosis between real death and apparent death or trance.

Electricity may be used to differentiate between true and feigned disease. Persons may feign disease, especially paralysis and anæsthesia, for the purpose of exciting sympathy in order to obtain charity, to avoid duty, or for the purpose of obtaining damage after accidents. Some malingerers may have sufficient control over themselves to bear without flinching severe pain, as produced by pricking, pinching, or burning, but it would be absolutely impossible for them to resist the contractions of the muscles when the faradic current of high tension is applied; also faradization of the skin with the wire brush will often be sufficient to decide whether the patient is shamming or not. As a general rule, in cases of paralysis, if the muscles respond to the faradic current after the patient has complained for fourteen or eighteen days, it is one of imposition. In speaking of the value of electricity in making a diagnosis, Haynes says: "In those difficult cases after railway and other accidents, when persons demand compensation for damages, the existence of the reaction of degeneration would be a fact of vital importance in favor of the applicant, or it would indicate that he was suffering from

severe injury of the nerves. Such a demonstration in a court of justice is more conclusive than any amount of authoritative opinion."

When the galvanic current is used on or near the head a metallic taste is noticed, and as the current is increased or the electrode moved from place to place flashes of light appear; these phenomena are due to the effect of the current upon the gustatory and optic nerves, and their reaction to galvanism is of great diagnostic importance as showing the power of these nerves to react to normal stimuli.

Electricity may be used to differentiate between ovarian pains due to organic lesions and ovarian pains which are simply nervous in character. Make vaginal or intra-uterine faradization; if the pain disappears or is greatly relieved by it, it is not of an inflammatory origin, but simply nervous; but if after one or two applications the pain is not relieved the diagnosis would be inflammation of the appendages.

The faradic current may be used to differentiate between central and peripheral paralysis. In paralysis due to central (cerebral) causes, the muscles do not lose their faradic irritability; while in peripheral paralysis, the faradic irritability slowly diminishes, and in fourteen days is lost.

THERAPEUTICAL SPHERE OF ELECTRICITY.

Electro-therapeutics is that science which treats of the study of electricity in its relation to disease; or, in other words, it is the application of electricity in the treatment of disease. Electro-therapeutics, therefore, includes both electro-medicine and electro-surgery.

As a remedial agent in many forms of diseases, electricity has assumed such an important position—a position rendering it worthy of being termed a polychrest—that the study of its nature and its action upon the human system in health and disease is absolutely essential to an earnest physician who has a regard for the best interests of his patients.

A great and universal error is taking for granted that the word "electric" covers a narrow or limited subject, while it really is but a common heading under which a large number of branches are grouped. For example, the distinct subdivisions are galvanic, faradic, static and sinusoidal currents, each with specific indications of its own.

The therapeutic sphere of electricity is sufficiently wide to be justly considered remarkable without proclaiming it a "cure-all," or a panacea for all the aches and ailments to which the human body is heir; but it is a most potent agent and one from which most satisfactory results can be obtained when used by the intelligent physician who understands its action and dosage as he understands the action and dosage of any other remedy; and we venture this assertion, that if electricity is applied with the discrimination and skill with which the scientific physician employs medicine or surgery, it will record a smaller proportion of failures than either one of these. Its chief field is found in that large class of neuroses, such as hysteria, paralysis, neuralgia, and spasmodic affections, which so frequently baffle us when other therapeutic agents are employed with but little success; the various disorders to which women are peculiarly inclined; also those disorders well known to be influenced by change in external circumstances of weather, seasons and climate.

Electricity, at one time or another, has been used for every disease under the sun, and, like every other measure for the treatment of disease, has been overrated, carelessly employed, and then pronounced to be worthless by individuals who are ignorant of the first principles of its use, who have, without paying any attention to the special symptoms of the various cases, undertaken to treat every case by this means.

Too much is often expected of electricity. We must not expect from electrical treatment that which it does not or cannot accomplish. We must not expect it to perform miracles, to relieve or cure affections in a few days that have resisted all forms of medication. We must not expect elec-

tricity to replace sclerosis with normal nerve tissue, or that hopeless, incurable paraplegics may be caused to walk.

Cases should be chosen for electrical treatment, for every case is not amenable to its use. Some diseases are affected more than others, while in still others, no benefit whatever can be obtained from its use; in fact, its use would be positively harmful. On the other hand, there are affections in which electricity will do more good than all other measures combined.

Electricity should not be depended upon alone to cure a case, but should be judiciously used in connection with internal remedies. Notwithstanding many cases could be cured by electricity alone, yet, in the majority of cases, a simultaneous internal treatment is of the greatest importance, and should not be neglected if we wish to increase the chances of success. In many instances, it will pave the way for, or act as a supplement to, the indicated remedy.

What can we expect to accomplish with electricity? We may expect by means of electricity to augment the circulation of the blood, to promote absorption, to quicken torpid nutritive processes, to excite secretion, to improve digestion, to stimulate muscular action, to revive nerve-activity, to heal ulcerations, to dissipate strictures and tumors, and to cauterize and destroy abnormal growths. It may be stated in general terms that electricity is indicated in all cases of poor nutrition, whether local or general, wherever there is defective assimilation—in short, where a general tonic effect is desired.

Electricity properly applied will equalize the circulation, and, through improved circulation, will improve the nutrition of any part of, or the entire system. It will stimulate the secretory organs, improve digestion, and regulate the bowels. It increases more often and more strongly, first, the secretion of saliva; then that of urine; and when it is strong, or administered often and for a long time, it excites the in-

testinal tract ; and when it is very strong, quite frequently it causes diarrhœa.

Electricity appears to effect its curative results first in acting as a general tonic to the entire organism. By stimulating the circulation, the whole vegetative system seems to put on renewed action ; glandular secretions are increased, absorption promoted, the waste of the system is carried off with greater rapidity, repair is increased in still greater proportion. Nutrition is increased, the vital nerve-force is endowed with greater strength, and the whole well being of the organism becomes increased to a wonderful extent.

The physiological effects of electricity are three-fold—stimulating, sedative and tonic. The stimulating effect is immediate, the sedative quickly follows, and the tonic comes on more slowly, and is the most important on account of its effect upon nutrition.

Anything that will change the nerve motion to and beyond the normal is a stimulant ; while anything that will change it to normal is a tonic or may be a sedative. Electricity is generally looked upon as a stimulant alone, and when its stimulating effect is obtained its use is discontinued, and the true benefits of the remedy—its tonic and sedative effects—are not obtained. A tonic is anything that will cause functional activity to tend towards normal ; a sedative is anything that will quiet nerve excitement ; it will cause functional activity to go beyond the normal under certain circumstances ; it will cause functional activity to approach the normal under certain circumstances ; it will quiet nervous excitement and nervous irritability under certain conditions.

When electricity is to be used as a stimulant, the effect is slowly manifested, but it is accomplished, and merges into a permanent tonic effect, and increases after each repeated treatment, even continuing after treatment is abandoned. In subacute or chronic diseases, where stimulants or tonics are indicated, electricity is generally indicated. The indication for its use is when the general nutrition is impaired and needs

improvement. It will build up a reduced system better and quicker than by any other means.

In the treatment of almost any chronic disease always remember that electricity properly applied will stimulate the circulation, and that the increased flow of blood will bring an increased amount of nutrition; that the contractions of muscular tissue produce the same effect as massage or gentle exercise; that the process of waste and repair may be promoted, and that the nutrition of the entire system may be improved through reflex action, as well as by direct effect of treatment—securing a constitutional, tonic, sedative and stimulating effect.

Electricity restores tonicity to enfeebled or paralyzed muscles, evokes nerve and muscle reaction, softens indurations, resolves exudates, breaks down adhesions, relaxes contractured muscles and tendons, stimulates the function of the central nerve cells, stimulates the peripheral distribution of the nerves to the skin, and is the great alterative and regulator of nerve and muscle function and functions of the visceral organs.

Electricity, when intelligently administered, gives most brilliant results in an increase of vital power. It is "Nature's own remedy," and restores vitality by its constitutional effects, and prolongs life in comfort and enjoyment. It promotes nutrition of every part it excites; produces marked local and general circulatory effects, and stimulates the vasomotor system. It increases both the appetite and the body weight when the latter has been reduced by impaired nutrition.

Through stimulating the liver and kidneys, by improving the general circulation, and through the effect upon the skin in starting gentle perspiration, electricity aids in carrying off through the natural channels of the body much effete matter. This is one of the best methods of purifying the system. It is a decided alterative agent, and this property gives special value to it therapeutically—its sedative property is very valuable in the treatment of many nervous diseases. In many of

the chronic diseases of the nervous system it is simply indispensable—they cannot be cured permanently without the aid of electricity in some form.

Electricity has a decided refreshing and soothing effect upon the entire nervous system, and is of great service in nearly all nervous diseases. It seems to have the power to restore the nervous equilibrium, so to speak, when disturbed. It also seems to have the power to arouse into activity nervous centers which temporarily, from functional causes, have become dormant.

Electricity is the best therapeutic means at our disposal to combat pain, hemorrhage, and impaired health and strength. Above all local means, not only for relieving pains of any particular paroxysms, but for effecting a permanent cure, electricity stands first. For the relief of pain electricity will usually act more promptly than morphine, opium, the bromides, chloral, and other drugs of this class, and is free from all the bad after-effects of these remedies.

The study of the control of pain is one of the most interesting in electro-therapeutics. Electricity is a great pain-reliever and will temporarily relieve almost any pain that can attack the living tissues, and eventually permanently cure a very large proportion of them. There are many instances, however (as in locomotor ataxia and cancer), where temporary relief is all that can be expected; but whenever electricity will palliate any incurable pain it possesses a decided advantage over morphine and other drug anodynes, for at the same time it is giving temporary relief it is also imparting a general nutritional benefit.

Nothing so readily relieves the intense suffering caused by rheumatic inflammation as the electric current, which will often succeed when all other means have failed. Neuralgia, when of idiopathic origin, is more successfully treated to-day by electricity than by any other medicinal agent. In many instances it is cured in a few sittings. Counter-irritation is a very popular treatment for neuralgic pains, and galvanism or

faradism afford a counter-irritant of great convenience in application. Electrical counter-irritation has the great advantage that it does not damage or destroy the skin as do blisters or the cautery.

In neuralgia, a good general rule for the application of electricity is, whenever pressure aggravates the pain, use the positive galvanic current over the sensitive point; and when pressure gives relief or does not aggravate the pain, use the faradic current.

In the treatment of paralysis of curable forms it is one of the most successful agents we have. In paralysis due to injury or diseases of the peripheral nerves, electricity does good in promoting and hastening cure, or in starting into activity again a stagnant reparative process. Muscles that have become too enfeebled to move the limbs will often be restored to full function in a remarkably short space of time.

In hemiplegia, the result of cerebral hemorrhage, electricity should be applied to the brain to cause absorption of the extravasation, and the progress toward recovery is far more rapid if a peripheral application to the nerves and muscles of the paralyzed extremities is combined with the central application. Caution, however, should be used in the use of electricity about the head where there is disease of the brain.

In paralysis, during childhood, electricity is a valuable means of restoring the power of the part, and if neglected during the early period of the paralysis irrevocable wasting of the muscles may follow. True, it will sometimes follow in spite of every care, but such a result is less frequent where precaution has been taken to keep up the nutrition of the muscle by due excitement of function.

It is in paralysis, depending on cornual myelitis—the poliomyelitis anterior both of childhood and the adult—that electricity finds its greatest field of usefulness in structural diseases of the cord. That electricity is incapable of restoring a cell once destroyed is quite true, but that it is incapable

of doing anything to arrest the further progress of a cell on the road to destruction, or of preserving contiguous healthy cells from degeneration, clinical experience abundantly disproves.

In facial paralysis electricity will hasten recovery in the mild forms, and in the severe forms will prove of great service in enabling us to keep up the activity and nutrition of the muscles during the temporary affection of the nerves, thereby preventing the development of secondary contraction and spasmodic conditions.

When from direct force or dislocation a nervous trunk lying near one of the larger joints has been pressed upon or lacerated, electricity produces its good effects by keeping up the tone and nutrition of the parts below during the repair of the injury.

The surest means of improving the nutrition and contractibility of the muscles is the process of muscular contraction itself; by this means muscles which are contracted and atrophied to a more or less extent can be brought up to their normal condition, and this can be accomplished more efficiently by electricity than by any other means; any muscle in the body can be thus stimulated by stimulating its motor point.

How does electricity increase the size of an atrophied part? In an atrophied condition, electricity, properly applied, will increase the flow of blood to the part. The improved circulation will bring more nutrition through the blood. The improvement in the process of repair, through improved nutrition, will tend to restore the parts to their normal condition.

How does electricity decrease the size of an hypertrophied part? An enlarged prostate gland, a fibroid tumor, subinvolution of the uterus, etc. (generally termed hypertrophic conditions), are not in the true sense of the meaning hypertrophies, but are conditions in which there is an increase of new tissue elements, due not to increased vitality and func-

tion, but the reverse. Electricity restores the normal equilibrium, increases the circulation and functional activity, and in this manner causes a reduction in the size of the part from a physiological standpoint.

Electricity will often relieve the nerve and muscular effect of traumatism, allay local inflammation, subdue pain, restore the circulation to contused parts, quicken the reparative process of nature, increase mobility of stiffened muscles and joints and tone up and strengthen the patient with greater facility than any other one procedure. In spasmodic affections, like writers' cramp and analogous conditions, electricity and massage are the only treatments of any value. In chorea it soon restores the equilibrium and allows the development of the system into manhood or womanhood without further trouble.

The various conditions associated with hysteria, such as paralysis, contractures, anesthesia, and hyperesthesia, are more or less amenable to electrical treatment, either general or local. It is often the case that a single application of the static sparks or of the faradic current to the throat for a few minutes will entirely dispel hysterical aphonia ; and in hysterical paraplegia, the anesthesia and motor paralysis will frequently vanish altogether in the course of three or four sittings. The hoarseness and loss of speech of public speakers and singers is often quickly removed by judicious electrical treatments. Mild treatments of short duration often repeated, with absolute rest between, is the rule to follow, to get the best results. Both the constipation and nausea that are so frequently associated with, and constitute a part of nervous dyspepsia, are disposed to yield rapidly and permanently to electrization.

The majority of recent cases of impaired functionation of the mind have either sleeplessness or active brain excitement, or mental torpor, or morbid motor activity, or the reverse, as part of their symptoms at some time. All these morbid

states are helped more or less by the judicious use of electricity in one form or another.

By the use of electricity many of those hitherto incurable diseases of the spinal cord are cured, many more are arrested, and in but a very small number does a judicious use of electricity fail to palliate the severity of the symptoms. In treating that great nervous center, the brain and spinal cord, both the galvanic and faradic currents excite muscular contractions, and direct electrization of the sympathetic nerve changes the calibre of the cerebral blood-vessels. The only difference is that the galvanic current acts more rapidly in those cases than the faradic.

Electricity begins its remedial effect immediately upon being applied, and is much more prompt in its action than many drugs. In nervous prostration, melancholia, anæmia, and, in fact, wherever a general tonic is indicated, its beneficial effects are noticed almost immediately, for patients rapidly gain weight and strength.

Electro-therapy in every disease where the nervous system is a factor will greatly help, if it does not of itself effect a cure. No one who has not had practical experience in its use can form an idea what power it has. Functional diseases of the uterus or ovaries may be relieved quite promptly by a properly selected current. "I can recall case after case of amenorrhœa in stout women who have been made to menstruate; sterile women who have been made to conceive; of women who have suffered untold agony at their menstrual periods, and for the most time between it and the next, who have been made to see the flow come without the slightest pain; and as to menorrhagia, I have never known it to fail." (A. Lapthorn Smith.)

For the treatment of endometritis, salpingitis, and the various diseases peculiar to women, in electricity we have an agent at once prompt, reliable, successful and efficient.

It is a well known fact that besides the improvement of the morbid conditions for which the electrical treatments are

given, the general health always improves, and the whole nervous system seems sometimes to be rearranged.

In the employment of electricity a point that is well to remember is, that though electricity removes some diseases all at once, as if by magic, still in others it must be used with patience and persistence for a long time, even though the patient may apparently be receiving no benefit from it at first. Later developments will show, however, that beneficial action of the current was progressive from the very beginning of the treatment. The effect of electricity is far-reaching and of long-continuous action. It traverses the tissues to their innermost depths, and produces profound modifications of structure and function in nerve and muscle, enduring for weeks after a single electrization.

Remember that the good results of electricity are due to the fact that it restores normal nerve action, thereby increasing nutrition; and that such results require time. In many cases it will require months, sometimes years, to restore functions to complete working order; also, in chronic and obstinate cases, the whole system has to be, as it were, regenerated, and this naturally requires time.

FORMS OF ELECTRICITY.

As to the forms of electricity, the electro-therapeutist of to-day has at his command the following currents: The galvanic, the faradic, the franklinic or static electricity, the sinusoidal, the electric light and the X-rays. The electro-cautery is not included, because practically it is only mechanical in its action.

Functionally, all electricity is one and the same, for electricity is always electricity, whether it is generated by a dynamo, by a chemical cell, by friction, or by induction. The difference lies only in varying effects produced by electricity generated in different ways, due to such special char-

acteristics as intensity and quantity which each may possess, and their effect upon the organism.

The three common forms of electricity, which we know as galvanic or constant, as faradic or induced, and as franklinic or static, result from their different manner of production, and are distinguished from each other by their rate and manner of discharge, which is constant and continuous in the case of galvanism, intermittent, inconstant and alternating in direction and intensity in faradism, and intermittently instantaneous in franklinism.

Respecting the effects of electricity on the organism, we find them of two fundamental kinds—namely, first, functional and second, molecular, and these are combined in different proportions in the case of each of the three common forms of current. In the strengths employed on the organism the galvanic current produces the least functional and the greatest molecular action; the franklinic discharge, on the other hand, the least molecular, and, for the same quantity of electricity, the greatest functional effect, while the faradic current holds an intermediate place.

Regarding the choice between the different varieties of electricity, sometimes one variety is more effectual and sometimes another. A physician cannot limit himself to any one of the varieties. In any given set of cases we cannot say that one current is superior to another. One current is inferior or superior to the other according to its individual use. We cannot say that the galvanic current is adapted only to one class of diseases, the faradic to another, and the static to still another. Although each current possesses peculiar properties of its own which distinguish it from its fellows, yet they are, in a greater or less degree, mutually interchangeable in all their important properties. Each form has its special uses and adaptations, and all are indispensable to him who makes much use of electricity in medicine. But they all have this in common, namely, *the capability of rousing the vital energy of the nerves.* Seldom is a patient treated by any one of

these methods whose general health, weight, facial appearance and feeling of well-being are not notably improved.

GALVANIC CURRENT.

Galvanism.

The galvanic current is so named in honor of Galvani, of Italy, who first discovered it in 1780. It is also referred to as the direct current, because flowing directly from the battery cells; constant or continuous, because the current flows without interruption; voltaic, after Professor Volta, who discovered a new and powerful method of producing this current, namely, the voltaic pile, from which all the galvanic batteries of the present day have been developed. This form of electricity is generated by chemical action, and is termed dynamic or current electricity—signifying electricity in motion, to distinguish it from static electricity—signifying the electrical condition of bodies in which the electricity remains insulated or stationary.

In galvanism the amperage of the current is of more importance than the voltage, the latter being made just high enough to overcome the resistance of the body to the flow of the current. The current may be continuous or interrupted; generally the former is used.

When using the galvanic current, it should be measured by the milliampere-meter, and care should be taken that the current is never reversed while the meter is in the circuit, as it would be liable to ruin it.

When using a meter, it is usually better to throw all, or nearly all, the cells in the circuit and govern the strength of the current by the rheostat; the voltage is greater and the cells are used equally, instead of some being entirely exhausted while others are scarcely used at all.

When a nerve is subjected to the influence of the negative pole, its excitability is increased (catelectrotonus); when subjected to the influence of the positive pole its excitability is diminished (anelectrotonus).

At and about the positive pole collect acid products, and at and about the negative pole alkaline products; and if the remaining intra-polar regions be microscopically examined, structural changes peculiar to each polar nucleus will be found to shade off in a degree toward the neutral central portions.

In galvanism we have an agent from which two forms of cauterization can be obtained, according as to which pole is employed; the positive producing an acid cauterization, the negative resembling that produced by a caustic alkali. It is thus seen that we have at our command an acid or alkaline caustic, which we can liberate rapidly or slowly, in any desired quantity, and which can be applied to any desired point, and can thus control its activity in a manner impossible of accomplishment by any other means. The eschar resulting from the caustic action of the positive pole is firm, dense, and retractile, while that of the negative pole is soft and yielding.

The galvanic possesses catalytic, cataphoric, electrolytic and distinctively polar actions. The polar action must be kept well in mind, for polarity means everything when employing the galvanic current.

To detect the direction of the current—that is, which is the positive and which is the negative pole—immerse the metallic tips of the conducting cords in water (a saline solution is better than pure water); the tip around which quickly gather bubbles of hydrogen is the negative; the blackening of the metallic tips at the positive pole will give similar indication; also a solution of iodide of potash and starch, when brought under the influence of the current, will give a blue color at the positive pole, while at the negative pole the solution remains colorless.

To detect whether any current is flowing or not, touch the tips of the conducting cords together. If there is a current flowing, an interruption of this current will produce a spark; or, when one sponge is applied to the patient, take the other

one in your hand, moisten the tips of the fingers or the palmar surface of the other hand, and make contact with the patient's body. A very delicate test is to place the electrodes against opposite sides of the face or tongue, when strong burning or prickly sensations will be felt on interrupting the current; or, again if the electrodes are placed on the opposite sides of the temples flashes of light will occur on moving the electrodes. The head and body is inclined toward that side where the positive pole is applied during the whole time the current is flowing, but on breaking the current they are turned toward the side corresponding to the negative pole.

In using the continuous current there is only a contraction on closing the circuit, whether the closing or opening is effected with the positive or negative pole. At the cessation of the current there is no contraction at all. At both poles there is a contraction of the arterioles, which quickly at the negative pole, and less quickly at the positive pole, becomes a dilatation.

The polar and intra-polar electrolytic action of continuous currents produces profound modifications of structure and function in nerve and muscle; in fact, the electrolytic action of the galvanic current is one of its most important properties.

If, in regard to the application of electricity, the theory is correct that a current is generated in the tissue fluids which flow from the anode to the cathode and that the physiological action is contraction and after a time relaxation or dilation of the blood vessels, the tissue changes within the circuit must be influenced and the nutrition altered.

In the galvanic current, the electricity always flows from the positive to the negative pole. The positive pole soothes, while the negative stimulates, excites and is more harsh and irritating. When the two poles are applied to the body and the current is turned on, the most chemical action and pain is produced where the current emerges from the body, and that is at the negative pole. This action of an electric current has been compared to the effects of a bullet passing through

the body, in which case the greatest lesion exists at the point where the bullet passes from the body.

In galvanism the effects of the poles are everything in therapeutics, each pole having its special field of action and its special indications; and with each pole there is a distinct polar and intra-polar action of the current; the polar action being that action which takes place at the point of contact of the active pole with the tissues, and the intra-polar action being the influence exerted by the current in its passage through the tissues, the greatest action being manifested in proximity to the active pole.

The positive pole may then be divided into its intra-polar and polar action. In its intra-polar action it is *anodyne*, *sedative*, *anti-congestive*, *denutritive*, *anti-hemorrhagic*, or *hæmostatic*, and *alterative*. It acts by contracting the capillaries; it will drive out congestion, allay inflammation, and will relieve pain. In its polar action it is *styptic* with moderate intensities, and *caustic* and hæmostatic with high intensities. The sedative or anodyne action is chiefly due to the liberation of acids at the anode, while the hardening effects are referable mainly to the liberation of oxygen and the non-metallic chemical elements at the same pole. These effects are for the most part electro-chemical, that is, partly electrical and partly chemical, even when the intensity of the current is comparatively weak.

The negative pole in its inter-polar action is *stimulating*, *congestive*, *derivative* and *alterative*, favoring absorption by increasing the blood-supply. In its polar action it is markedly *electrolytic*, *liquefying*, producing active chemical decomposition, and *caustic* with much lower intensities than the other pole. These effects are in part explained by the fact that the alkalies and fluids are precipitated at the negative pole, since both alkalies and fluids have a softening effect on the tissues. Stimulation at the negative pole must also have the effect of increasing the secretions at the cathode, the stimulation being partly due to electricity and

partly to chemical action, for it is a well-known fact that alkalies increase the sensitiveness of the nerves.

In a general way, the positive pole is known as the coagulating pole, while the negative is the liquefying or dissolving pole, and that which promotes absorption.

Positive electrolysis is of great value in the treatment of varicosities, aneurisms, ulcerations, endometritis, subinvolution, menorrhagia, etc., by the styptic or coagulating power which it possesses. From the fact that acids attack the positive electrode and dissolve it, if it be copper, zinc, etc., we find its value enhanced where the deposit of salt of copper, zinc, and other metals are indicated. Negative electrolysis is especially useful in urethral stricture, cervical stenosis, discussion of fibroids, etc. The positive pole is a vaso-constrictor while the negative is a vaso-dilator.

The anode or positive pole of a galvanic battery is the sedative pole, and the cathode or negative pole is the stimulating or irritating. To produce the most pronounced sedative effect and allay irritability make stabile applications of the positive pole, galvanic current. To produce the most irritation, use the negative pole of the galvanic battery or reverse the polarity frequently. The sedative effect of the anode determine its use in neuralgia, sciatica, spasms, and tinnitus aurium, while the stimulating effects of the cathode and the greater ease with which it causes muscular contraction have determined the use of the negative pole in paralysis. In paralysis the negative pole is of greater service on account of its greater stimulating properties. This is true whether one is using direct or alternating currents. The positive pole has a greater contracting power upon unstripped muscular fiber than the negative.

Wherever sensory nerve action is abnormally increased, causing pain, neuralgia, hyperesthesia, the anode of a continuous current applied over it for a few minutes will produce in the immediate vicinity of the electrode a sedative effect, provided the current has been used strong enough, and has not been

removed suddenly but gradually; that is, the strength of current carefully decreased to zero before the electrode is taken away. On the contrary, if the sensory nerve action is dull, sluggish, the area supplied by it numb or anesthetic, the application of the cathode will arouse and stimulate it and increase its irritability, and this effect remains for some time, provided the same precaution is taken to withdraw the current gradually.

The action of the positive pole is that of a hemostatic. In an open blood-vessel the positive electrode will produce a hard, firm clot; while the negative electrode produces a soft clot. This fact has been taken advantage of in the treatment of fibroid tumors of the uterus.

Helmholtz has shown that a nerve is less sensible in the presence of an acid; the effect, therefore, of the acid determined at the positive pole is to remove the nerve condition—in other words, is anodyne.

The negative has a stronger effect on the nerves of the skin than the positive. Often the patient will complain of a burning sensation at the negative pole, while at the positive pole no sensation at all is felt.

A metal electrode, attached to the positive pole, should not be allowed to come in contact with the mucous membrane. Use the "Soluble Electrodes," copper, zinc, etc.

Hyperæmia and erythæmia are more easily produced in women and in persons with a delicate skin; and are more marked at the negative than at the positive pole.

The negative pole—stabile—of the continuous current possesses the most value in the absorption of exudates. This may be due to the principle of cataphoresis, according to which an increased amount of fluid is directed to the cathodic end of a semi-fluid electrolyte.

That absorption takes place more readily at the negative pole than it does at the positive, has been established by an abundance of clinical evidence, especially in the case of cicatricial tissue, which is rapidly absorbed by direct applica-

tions of the negative electrode. The negative favors absorption by liquefying the tissues.

The galvanic is the only current that can be used in removing superfluous hairs, facial blemishes, hemorrhoids, stenosed canals and strictures; or, wherever the process of electrolysis or cataphoresis is to be employed. Electrolysis is the only known method to insure permanent destruction of hairs on the face, with little or no resulting deformity. In the removal of facial blemishes, electricity is practically the only treatment that we have that is efficient.

In the treatment of strictures of the urethra, cervical canal, rectum, or œsophagus, electricity is the pleasantest, safest, and most efficient treatment, and the galvanic is the only form of current to employ.

That the negative pole of the galvanic current has the power to soften or dilate a stenosis of the uterus is a fact that can be satisfactorily demonstrated in any case where it is employed. Only the negative pole should ever be used when making applications to the urethra, or to any stenosed canal.

The negative pole in the uterus when you want to stimulate it to increase the blood supply. The positive pole in the uterus for endometritis and hemorrhage. The positive pole in the uterus when it is soft and congested; the negative when it is hard and you want to relax it. Atrophy of the uterus, or an undeveloped uterus—negative pole in the uterus, positive pole on the abdomen or over the lumbar region.

The most powerful contractions of the uterus occur when the current is directed from the spine to the cervix—that is, positive pole to the spine, and negative pole to cervix uteri. The positive pole should rarely, if ever, be used in the uterus or vagina when there are any indications of pus-accumulation in the tubes.

For the treatment of endometritis there is probably no method or means that has ever been discovered more effective than the intra-uterine application of the galvanic current. In simple endometritis or uterine catarrh, galvanic currents

locally applied are practically infallible. When the endometritis is associated with slight cervical lacerations, it will usually be found unnecessary to perform the operation for repair, as all symptoms disappear under this treatment, leaving the patient practically well, even though a slight irregularity in the cervix remains. The choice of pole is governed by the presence or absence of menorrhagia, the positive pole being always used with this complication.

The galvanic current is of great utility in causing absorption of old exudations in any part of the body, but is of special use in removing thickening and infiltrations resulting from inflammation of pelvic cellular tissue.

It will not only absorb the slight exudations which merely produce thickening of the vaginal vault, but it will cause the rapid disappearance of large well-defined masses situated in the broad ligaments, or in Douglass' cul-de-sac. It will cause the disappearance of strong bands of adhesions, no matter where situated.

In tumors of the uterus, fibrous or fibro-cystic in character, associated with hemorrhage, galvanism not only checks the hemorrhage, but seems to have a direct influence upon the growths, often reducing them in size, and that without puncture.

It will cause ovaries, large and tender from the irritation of inflammatory products, to assume their normal condition by removing the cause of the trouble. A continuous current, applied externally over the abdomen, above the pubes, is of marked benefit in cases of scanty menstruation. The galvanic current will excite the menstrual flow when absent in many cases, decrease it when profuse, and often relieve pain when present.

The galvanic current will promptly relieve neuralgia of the urethra. The cathode should be placed in the vagina and the positive over the bladder, and a current of from 10 to 15 ma., passed for a few minutes, or until relieved.

Electricity is highly commended in the vomiting of preg-

nancy and often it succeeds when all other means have failed. The positive pole is applied over the lower cervical vertebræ and the negative over the epigastrium.

The galvanic current is a powerful stimulant for all the different portions of the nervous system, and these stimulating effects become more particularly developed where an intermittent application is resorted to. It has the power of awakening the excitability of a nerve after all other stimulants have ceased to act. When a muscle has lost all power of responding to the stimulus of a faradic current, in many cases its sensitiveness may be restored by the application of a tolerably strong galvanic current. In many cases of peripheral paralysis galvanism will surpass faradism.

Galvanic electricity promotes in the highest degree the nutrition of the tissues, while from the application of the faradic the motor and sensory nerves are mechanically affected, stimulating the muscles to contraction; hence the galvanic current is indicated, if paralyzed muscles do not respond to the faradic.

Simple peripheral paralysis, resulting from cold or pressure, and unaccompanied with inflammation, may be treated successfully with the faradic current, but where a modifying molecular or nutritive effect is required, the galvanic current alone can generally be relied upon to yield the requisite catalytic effect.

The galvanic is best in nervous ailments, the faradic in muscular troubles, although it is often of benefit to use both in either ailments. The galvanic current operates more powerfully by reflex action than the faradic on account of its continually flowing in one direction.

The galvanic current affects the nervous system more profoundly than the faradic. It will also, by reversals of the current direction, cause muscular contractions in some cases where the faradic current fails. It produces greater molecular changes in the tissues, and possesses greater catalytic action. Frequent interruptions of the current or changes of polarity

intensify the effect of the current and are often necessary to relax tense muscles.

The galvanic current has a greater effect upon nutrition, and will stimulate the absorbents and assist in removing hypertrophies, effusions and morbid growths where the faradic current would be useless. It increases the activity of a gland, and consequently its secretions.

Galvanism is the most active stimulant of nutrition we have, and in all those morbid affections suffering from malnutrition and malassimilation the organs of digestion and absorption are stimulated to the proper performance of their functions.

Galvanism exerts a powerful influence on the vaso-motor and trophic systems of nerves. It produces direct stimulation of the vaso-motor nerves, which latter transmit the influence to the blood-vessels and lymphatics. In this way the process of nutrition throughout the system may be influenced. Galvanism of the cervical sympathetics is one of the best methods to effect this result. By catelectrotonos of the vaso-motor nerves absorption is promoted, and effusions may thus be removed into the general circulation.

One of the most prominent characteristics of this current is its power of relieving pain which is promptly manifested, particularly in certain neuralgic conditions. In the majority of cases patients come to us for electrical treatment for the relief of pain. If we desire to relieve pain most promptly, we will employ the galvanic current, positive pole over seat of pain, stabile applications, use sponge or absorbent cotton electrodes, covering considerable surface and turn on the current (after electrodes are in position) slowly, and at the end of treatment, turn it off slowly.

In using the galvanic current for the relief of pain, care should be taken that the electrodes are not lifted from the surface, as this breaks the current and produces a shock; that the current is not abruptly broken and polarity not reversed.

In the acute pains of facial neuralgia and the persistent aches of spinal congestion, the judicious use of galvanism has succeeded better than any other treatment.

Frequently the lancinating pains of locomotor ataxia, especially when associated with circumscribed spots of hyperesthesia of the skin, will disappear as if by magic from the application of the galvanic current—the positive pole over the spine and the negative pole applied to the painful spot.

In treating stiff and inflamed joints, immerse them in salt water with the pole required.

If an inflamed condition exists, galvanism will destroy it by electrolytic action, which brings nutritious blood into the engorged tissue—due to the hyperæmic condition produced by the electrode, thus acting as a counter-irritant and at the same time oxygenizing the blood.

Nervous deafness, hysterical deafness, and even deaf mutes, have all been benefited and cured by the galvanic current.

In cerebral hemorrhage, decided benefit can be obtained in the stage of absorption and beginning convalescence by the application of the galvanic current to the brain; in addition, peripheral treatment of the paralyzed, anesthetic, or atrophied parts will be required. The objects aimed at in applying the electricity to the head in cerebral hemorrhage are: (1) To promote the absorption of extravasated blood; (2) to assist the circulation through the brain; (3) to remove œdema and congestion; (4) to improve nutrition.

It is possible by means of the galvanic current to detect good teeth from bad ones. The passage of the current through the teeth gives rise to no discomfort when healthy; but its application to a decaying tooth is followed by violent pain, and an involuntary motion of the body; by employing this diagnostic measure there will be no possibility of removing a sound tooth by mistake.

There is no treatment that will so quickly disperse a swelling or remove by absorption an enlarged lymphatic gland as electricity, if properly applied. The galvanic current should

be used in all cases. The negative pole should be applied to the affected part, and currents of moderate strength applied five minutes daily. In treating enlarged glands, if the negative sponge be thoroughly moistened with tincture of iodine, it will greatly hasten absorption. Almost every case can be prevented from coming to suppuration if this treatment is employed. From two to six ma. of current may be used, or five to eight cells.

Small operations upon the limb, opening of boils, felons, etc., may be done under the electric anæsthesia, if aided by arrest of circulation. If it is the hand or arm to be operated upon, stop the circulation by a tight bandage, then apply cocaine and aconite with positive pole until the part is thoroughly anæsthetized. Cocaine anæsthesia is more quickly produced, is more enduring in its effects and necessarily requires less of the drug, by this method, than by the usual injection without arrest of circulation.

As has been said before, in the application of electricity, we must not lose sight of the fact that it is of importance to use a certain pole to accomplish certain results. The difference of the physiological effects of the galvanic current at the different poles when applied to the body is of radical nature.

In regard to choice of polarity in any given disease, Professor Morton has advanced the hypothesis that both physiological and pathological chemism (metabolism) must exhibit a polarity which he has termed "metabolic polarity," and has proposed, as a basis of treatment, that a given polarity of disease have applied to it an extraneous battery polarity of the same or opposite name, in order to augment or diminish the chemical exchanges underlying it. Of the workings of this hypothesis he says: "It follows that when chemical exchanges, metabolism, are excessive (*a*) a positive pole will increase the excess, augmenting the disease; (*b*) a negative pole will diminish the disease; but if the chemical exchanges are underactive, (*a*) a positive pole will increase the under-

activity; (*b*) a negative pole decreases it. In overactivity of metabolism a negative pole, in underactivity a positive pole is palliative or curative.

Applying this hypothesis to the treatment of disease, he would apply the negative pole to all inflammatory—overactive—processes, and the positive to all torpid or degenerative—underactive—processes.

In using the galvanic current, the treatment should be commenced with a very mild current, gradually increased to the desired point and then decreased before the electrode is removed. A mild galvanic current produces no unpleasant sensation beyond a slight feeling of heat or burning beneath the negative electrode and a slight numb sensation beneath the positive electrode.

The galvauic possibly occupies a wider field of therapeutic usefulness than does either faradic or static electricity. When the galvanic current is artificially interrupted, it is known as the *interrupted galvanic current.*

The interrupted galvanic current has greater stimulation and irritation than the direct current, and is the most useful in treating obstinate cases of rheumatism, muscular atrophy, local anæsthesia, paralytic conditions, and a similar line of diseases; it is of decided advantage in a certain range of conditions, but is rarely used as compared with the direct.

The interrupted galvanic current is used where it is desired to produce strong mechanical effects. The slower the interruptions the more vigorous will be the muscular contractions. In some chronic and exceedingly obstinate cases where the faradic current has little effect, if any, the interrupted galvanic current will produce the desired result.

Involuntary or unstriped muscular tissue responds more slowly to any form of stimulus than the striped variety, and consequently a slowly interrupted galvanic current is better calculated than any other artificial agent to excite contraction in this variety of muscular tissue, and does so with the least possible harm. Now when we consider how universal

is muscular tissue of one or the other variety in all parts of an animal organism, and how largely the functions of the body are dependent upon its action, the therapeutic value of an agent that can excite this tissue, when for any reason its action is feeble or faulty, becomes manifest. Involuntary muscles in the digestive tract can be thus influenced, when this effect is required, as in the atony of the stomach or torpid peristaltic action in the large or small intestines, resulting in constipation. Local weakness of circulation, giving rise to passive congestion of liver, spleen, lungs, uterus or central nervous system, can be relieved by stimulating the muscular structure in the arterial tunics. The gall bladder can be evacuated by like means when overdistended by reason of feebleness of contracting power, while a voluntary muscle in any part when feeble, atonic, paretic or paralyzed from faulty innervation can be brought into action and its nutrition quickened. Therefore, therapeutic applications of the constant current can be made to muscular structure with the view of exciting its function and improving and maintaining its nutrition when it has suffered impairment by reason of abnormal conditions originating in the muscle itself, or secondary to disorder in its governing nerves.

The main difference between the faradic and the interrupted galvanic current is that in the latter the current is not being reversed, as in the faradic, and there is a much greater chemical effect, and a large number of cells, or more current, can be used with the same amount of pain.

The galvanic current may be used as: (1) Subaural Galvanization; (2) Galvanization of the Sympathetic; (3) Central Galvanization; (4) General Galvanization.

Subaural Galvanization.—This term has been applied by Dr. Watteville to a method of treatment in which the negative electrode is placed just below the ear, and the positive over the cervical and upper dorsal vertebræ, a current from 5 to 10 cells being placed from three to four minutes on one or both sides.

Galvanization of the Sympathetic.—Althause gives the following methods: (1) One electrode is placed in the auriculo-maxillary fossa, and the other on the transverse process of the sixth or seventh cervical vertebræ, on the opposite side of the body. By proceeding in this manner, not only the upper cervical ganglia are affected, but the spinal cord and the base of the brain likewise receive the ganglionic influence. (2) One electrode is placed in the auriculo-maxillary fossa, and the other at the manubrium sterni, at the inner edge of the sterno-mastoid muscle. This mode of application not only affects the upper and lower cervical ganglia, but also the pneumogastric, the depressor nerve, the laryngeal, and the descending branch of the hypoglossal nerve. (3) One electrode is placed in the auriculo-maxillary fossa, and the other inside of the cavity of the mouth, opposite to the articulation of the lower jaw. This mode of proceeding would localize the current in the upper cervical ganglia of the sympathetic.

Galvanization of the sympathetic influences the vasomotor and trophic processes of the brain and spinal cord, the face, eyes, muscles, skin, and many parts of the body, and produces a feeling of sleepiness and drowsiness, which commences soon after the current is closed, continues during the application, and for some time after the current has been broken.

Central Galvanization.—Beard has proposed a method which he calls central galvanization. He recommends that the negative pole be applied to the epigastrium, while the positive is applied over the head, around the sympathetic and down the whole length of the spine, in such a way as to bring the brain, the pneumogastric, the spinal cord, and all the prominent plexuses of the sympathetic—indeed, the whole central nervous system—under the influence of the current. The negative pole should be placed on the pit of the stomach, because it is well borne there, and because the descending current (electricity flowing from the positive to the

negative pole) seems to act better in most cases than the ascending. The positive is less acutely felt than the negative and is less irritating, and he thinks it is not unlikely that this fact may explain the more satisfactory results of the descending current in central galvanization. The structures mainly influenced by this method are the medulla, the pneumogastric nerve and the sympathetic system.

This method of applying electricity is especially useful in those nervous affections (hysteria, neurasthenia, sleeplessness, and dyspepsia) characterized by nervous exhaustion, the muscular strength and the general nutrition not being much impaired; or, in other words, in cases where the symptoms are not very well defined, and where there is a low state of nervous power throughout the system.

In beginning a treatment, always begin with a mild current and increase, if necessary, as the patient becomes more tolerant of its effects. It is rarely necessary to employ a current so strong as to cause distress; but it is necessary to produce a plainly perceptible feeling of pricking and of heat; also the current should be given sufficiently strong to produce a metallic taste in the mouth when it is applied to the head and neck. Vertigo should be avoided if possible. The duration of treatment should be about ten minutes, the sitting should be twice or three times a week, according to the severity of the case, until twelve or fifteen applications have been given, or until decided improvement has set in, and then once a week until five or six have been given.

A modification of the above method, and one which answers for all practical purposes, is to place the positive electrode (a large one) to the nape of the neck and the negative (a small one) over the pit of the stomach. The electrode over the pit of the stomach should be held stationary for about five minutes and then moved over a larger area, usually including the greater part of the abdomen in the circuit. The whole duration of the treatment should be ten or twelve minutes.

The concentration of the current over the pit of the stomach by means of a small electrode stimulates the *great solar plexus*, or "abdominal brain," as it sometimes is called, which is located near the median line of the body, under the pit of the stomach.

General Galvanization.—General galvanization, which was brought into prominence by Beard and Rockwell, is done as follows : One electrode is placed upon the feet ; it should be so large that it can be retained *in situ* during the sitting without discomfort. The other electrode is passed successively over the different parts of the whole body—the limbs, the back and the spine, the abdomen, the neck, and, lastly, the head. The object sought is two-fold—the stimulation of the whole nervous system through the muscles, skin, and peripheral nerves, and the inhibition of morbid, central nervous processes. General galvanization acts as a tonic to the entire system, but decidedly so on the nervous system.

FARADIC CURRENT.

Faradism.

The faradic current is named after Faraday, who, in 1831, discovered that a galvanic current passing through a wire induced a current in another wire near to and parallel to it. This current is also known as the "induced" or "interrupted" current. While the faradic current is generated by the same elements that generate the galvanic current, still it differs widely from that current in its properties and therapeutic effects ; for while the galvanic is a continuous current flowing in one direction, the faradic is an indirect, induced current—an interrupted current ; the current from the generating cell being modified by passing through a helix inclosing a bar of soft iron or a bundle of soft wire—or, rather, this core of soft wire becomes magnetized as the current is broken.

Being an interrupted current in which the intermission is greater than the period during which the current flows, there

is practically no chemical or electrolytic process to be taken into account.

The question of polarity in faradism is not as important as in galvanism, still the negative pole is the more irritating, and will be the pole of choice where much stimulation is required.

The negative pole can always be distinguished from the positive by its sharper current and greater effect on motor and sensory nerves. In the short, heavy coils the negative pole is more marked than in the long, fine coils.

The effect of the faradic current, when first applied by means of moistened electrodes, is to cause a tingling sensation, more noticeable at the negative than at the positive pole. In a short time the sensation becomes less and less marked, and a sort of anæsthesia is produced, enabling the patient to endure an increasing strength of current with no discomfort.

In treating patients of a very sensitive organization, the faradic applications can be rendered more acceptable by employing a rheostat in the secondary circuit for increasing the current, because the increase is made more gradual. The secondary coil is advanced all the way over the primary before the current is turned on through the rheostat. By this means the current is rendered more effective also, because the secondary coil is receiving the full influence of the primary throughout the entire application. If a rheostat is employed in the battery circuit, the rheostat in the secondary circuit is not so necessary, the same end being thus accomplished.

There is no instrument for measuring the strength of the faradic current, as the milliampèremeter for the galvanic current, but the strength of the current has to be regulated according to the parts being treated and the sensations of the patient; the strength being just sufficient to cause a gentle thrill—never pain; its volume being of the static order no harm can be done to the tissues.

In the different makes of faradic batteries, some have two coils and some three or more, but for all practical purposes a description of the properties and uses of two coils will suffice: (*a*) The *primary* current—the current from the short, thick wire; (*b*) the *secondary* current—the current from the long, fine wire.

The shorter and thicker the wire constituting a coil the greater quantity of electricity, while the quality or intensity is diminished. On the other hand, the longer and finer the wire the less the quantity, while the intensity is increased.

The primary current has very little effect upon the skin; it excites more acutely the subcutaneous organs, and especially the contractile power of the muscles, which are better conductors than the skin. The secondary current possesses a high tension and affects the muscles less and the nerves more than the primary current. It also affects the sensibility of the skin more intensely and produces more marked reflex contraction than the primary current. In short, the difference between the two currents may be summed up as follows: The primary current is a current of volume; the secondary is a current of intensity. The primary produces stimulation; the secondary sedation. The primary acts on the muscles; the secondary on the nerves. Following is a comparison of the primary and secondary currents:

1. The primary current is composed of a single current, always going in the same direction.	1. The secondary current is composed of two currents going alternately in contrary directions.
2. The primary exhibits galvanic properties, in that it deflects the galvanometer and possesses feeble electrolytic power.	2. The secondary does not deflect the galvanometer, although it may cause a very delicate needle to oscillate slightly.
3. The primary has more power to excite the sensory and motor nerves of the muscles.	3. The secondary excites more acutely the cutaneous nerves and penetrates more deeply into the tissues.
4. The primary is relatively less rapidly interrupted.	4. The secondary possesses distinct properties in virtue of its rapid interruptions, and far surpasses any other form as a stimulant to the nerves of sensation.

Duchenne claims that the difference in the physiological action of the primary and secondary currents is due to the fact that the former acts chiefly on the contractile power of the muscles, while the latter has more effect on the sentient nerves. Becquerel claims that the difference in the physiological effects of the two currents is chiefly due to the difference which exists between the tension of a short, thick wire and a long, fine wire.

The sensations produced by the faradic current will vary according to the tension of the electricity used. If the electricity be of low tension, it causes a slight pricking sensation; while if it be of high tension, intolerable pain may be produced.

When a slowly interrupted faradic current traverses a motor nerve, a muscular contraction occurs at each break, but if the interrupter vibrates rapidly the contraction becomes tetanic; similar stimulation of a sensitive nerve causes pain, and of a mixed nerve pain and motion. When the number of interruptions is less than twenty a second, each causes a distinct muscular contraction, with a distinct sensation. With more rapid vibrations a tetanic contraction is caused. Then the contractions occur in such a quick succession that there is no time for a perceptible relaxation, and they are so rapid that they appear continuous, the intervals between being too short to be distinguished; such contractions may be very painful. When, however, three hundred interruptions take place in a second, the muscular contractions cease, and the painful sensations disappear.

The effect of the faradic current varies with the number of interruptions. Sedative effects are best attained by the utmost frequency of interruption, a rapid interruption—20,000 to 50,000 per minute. On this point, Dr. W. F. Hutchinson says: "While it is true that general suffering must yet be fought with some drug that will rapidly pervade the system through the circulation and allay it by impressing nervous centers, I believe that the time has come to announce *that*

all forms of localized pain, not dependent upon structural changes of nerves or nerve-centers, or destructive metabolism of other tissues, may be relieved promptly and effectively and often cured by an induced electrical current, whose interruptions are sufficiently frequent and whose strength is small. Also, that by the same means there may be produced a local skin anæsthesia sufficient to permit of minor surgery, such as opening felons, being made." This analgesic and anæsthetic condition is brought about by paralyzing the terminal sensory nerve loops by swift movements.

The therapeutic value of rapid interruption rests upon our ability to employ strong, efficient currents without discomfort, and is found in the nerve-quieting, sedative effects of this interruption with fine coil currents. Remember this: the more rapidly the current is interrupted the greater the effect upon the sensory nerves.

Muscular effects are best attained by slow interruptions—interruptions sufficiently slow as not to overtire the muscle. This slow interrupted current is obtained by working the screw which withdraws the hammer attached to the platinum spring.

The faradic current has much more marked effect in producing muscular contractions than has the galvanic, but does not possess the chemical or electrolytic action.

The slowly interrupted faradic current, when locally applied to an individual muscle, causes a contraction, and indirectly such contraction means more blood to the part and, therefore, increased nutrition. The beneficial results which follow the use of the faradic current are largely due to the muscular contractions. There is increased activity of muscle and cells, and a call for increased nutrition in the muscle, creating a demand for the excessive nutrition, which has been primarily sent to the nervous system. This will in time restore the equilibrium between the nervous and muscular systems and the aches and pains disappear, feeble and

relaxed muscles become firm and strong, and the patient is restored to health.

This property of the faradic current to produce muscular contraction with comparatively weak currents renders it a powerful mechanical hemostatic in cases amenable to muscular compression, and is most efficient when, as in *post-partum* hemorrhages, both the tissues directly involved and those of the surrounding structures are brought under its influence.

The faradic current produces the physiological effects in the highest degree, and, at least therapeutically, should leave no resultant product of chemical decomposition behind it, since its decompositions are no sooner effected than a recomposition ensues.

The faradic current causes changes in the circulation. At first there is anemia, which is due to the contraction of arterioles, which contraction is due to the action of the current on the vaso-motor nerves. This anemia lasts only a short time, when the second effect comes on, which is hyperemia; this is due to the dilatation of the arterioles, which is the result of the secondary effect of the current upon the vaso-motor nerves.

It contracts blood-vessels as well as muscles, increases peristalsis in all non-striated fibers, stimulates every part of the nerve, whether cell or fiber, excites nerves of special sense, quickens the circulation and glandular secretions, combats blood stasis, relieves congestion, and promotes the absorption of effusions and the elimination of product waste. The processes of oxidation are quickened, the elimination of urea, carbonic acid and water is increased, and incomplete food combustion is more completely carried on.

The faradic current produces a sort of interstitial massage, heightening the circulation, accelerating the process of absorption, and influencing favorably the nutrition of the parts.

The faradic current, properly applied, accomplishes a variety of purposes: The effects of currents through the

different coils varies as much as that from the different poles of the galvanic battery; one gives pain, the other eases it; one reduces swelling, the other aggravates it: one gives a feeling of heat, the other of cold.

Whenever you wish to produce sedation or muscular stimulation, you should employ a faradic current. Use a coil of long, fine wire and rapid interruptions when you wish a sedative effect, and a coil of short, coarse wire with slow interruptions for a mechanical or stimulating effect.

The best method of lessening irritability with the faradic current is to begin with a very mild current, gradually increase it to the highest point that does not produce pain, and after holding the electrode in position for a few moments gradually reduce the strength of the current.

In using the secondary coil of fine wire for its sedative effect, the interruptions should be of the maximum rapidity and be smooth without jerk or shock; also the current intensity should be increased very gradually, otherwise it may have a very irritating effect upon the diseased structure, as well as being unpleasant to the patient.

By increasing the length and number of turns of the secondary coil and increasing the rapidity of the vibrations of the interrupter, the current derived from the secondary coil is made to approach more nearly in physical and physiological properties the sinusoidal current as at first used.

The secondary coil produces a current having much greater penetrating power than the primary current. It will more easily overcome resistance on account of its greater tension, and is to be preferred to the primary current in treating deeply-seated conditions, and is much more pleasant in its effect, particularly to nervous subjects.

The long, fine wire coil is of especial value in stimulating the vaso-motor nerves and the capillary circulation. This current produces contraction of the blood vessels and an increase of the vermicular movements, which increases the cir-

culation. This hastens the absorption of effete products and combats blood stasis, thereby relieving congestion.

The current from the fine wire coil is of special use in allaying pain and establishing local anæsthesia. The relief afforded by the employment of the current from the long, fine wire coil is just as certainly permanent as that afforded by opium or any other sedative, if the exciting causes which are active in giving rise to the pain and congestion are removed.

The primary current is very useful in relieving pain almost instantly from bruises and sprains, also to hasten the healing of cuts and sores.

The pain, swelling and venous distension of a contusion can often be quickly relieved by the primary current; the secondary would aggravate. On the other hand, the pain of a cellulitis or other pelvic irritation will be relieved by the secondary, while it would be aggravated by the primary current.

The secondary faradic current is of special value for the removal of ovarian pains where no organic lesions can be found; also in cases of abdominal pain due to hysteria it acts promptly, not only in rendering the abdomen insensitiveness to pressure, but also in calming the general nervous crisis within a few minutes.

Generally speaking, the current from a long, fine wire allays pain, quiets excitability, relieves congestion, and hastens absorption of inflammatory deposits, while the current from a short, thick wire causes muscular contraction and thus builds up the muscular system and promotes nutrition.

The faradic current is indicated in all hæmorrhages from the uterus due to relaxation of muscular fibres, in the hæmorrhages attendant on subinvolution, in *post-partum* hæmorrhages, and, to some extent, in hæmorrhages of fibroids. Not only uterine, but other forms of hæmorrhages, especially from the rectum, can be modified or checked entirely by means of the faradic current.

Uterine hypertrophy, hyperplasia, and even fibroid tumors, may have their growth arrested and be greatly reduced in size under the use of the interrupted current. By its direct excitation of the smooth muscular fibers of the uterus we are enabled to contract that stasis of the circulation which is the beginning of uterine inflammation. By this method we obtain a veritable interstitial massage that is potent in overcoming the primary inertia of the organ, and in preventing an arrest of retrograde metamorphosis, through which comes sub-involution with its inevitable and persistent sequelæ.

In pelvic exudations, even in the inflammatory stage, vaginal bipolar faradization can be employed with marked improvement in the disease and comfort to the patient.

By the use of the faradic current the uterus and its appendages can be developed by causing a greater flow of blood to them. If the faradic current is directed *longitudinally* through the uterus, it promotes powerful and genuine uterine contractions; but if passed *transversely* through the organ it excites partial contraction only in the direction of the current.

Amenorrhœa, due to arrest from cold, getting the feet wet, etc., can be usually overcome by bipolar intra-uterine coarse wire faradic treatment. This line of treatment should rarely be resorted to in young girls, for obvious reasons.

The secretion of milk may be much stimulated by faradization of the breasts with strong currents.

Flatulence can often be quickly relieved after all other measures have failed by the application of a mild faradic current to the abdomen, using a large electrode over the back.

Dropsy of the abdomen, due to various causes, has been successfully treated by faradization of the abdomen.

The quickest way to get rid of a pelvic enlargement, which is due to the wearing of corsets and the fatty muscles in the abdomen, is to stimulate the motor points of the abdominal muscles, and of the intestinal nerves by means of the faradic current.

An application of the faradic current to the head in many forms of neuralgia, nervous headache and insomnia, if properly given, is capable of affording instant and most grateful relief.

The faradic current is used to improve the impaired nutrition of a paralyzed limb or limbs. In the treatment of paralyzed or wasted muscles by faradism, the paralyzed muscles can be faradized directly by the application of the active electrode over their surfaces or indirectly by its application to their motor nerves; in either way similar results are obtained.

In the treatment of paralyzed muscles that still retain their faradic irritability, the faradic current is a more powerful agent than galvanism.

In neuralgia, the *faradic* current is to be preferred where firm pressure relieves the pain or does not increase it, and the *galvanic* where the pain is increased upon pressure.

The faradic or interrupted current cures disease mainly through physiological and mechanical processes, producing no appreciable chemical effect in the tissues.

Tension and quality are the most important therapeutic factors of the faradic current. In general terms it may be stated that the faradic current is to be preferred in muscular troubles and the galvanic in nervous diseases. All forms of electricity have a marked action upon the muscular fiber cells, but more especially so the induced current.

Where the object is to obtain stimulation, faradism is the best form of current to use. The faradic excites more acutely the cutaneous nerves, and penetrates more deeply into the tissues. It far surpasses any other form as a stimulant to the nerves of sensation.

Electric nerve excitation depends on *variations* in the amount of the stimulus, and not on the *absolute quantity* of current. For this reason the functional activity of faradism is greater than that of galvanism, as the relative *changes* in the

quantity are greater, even if the absolute quantity is not so great.

The faradic will stimulate the circulation and improve nutrition. Nutrition is improved by the increased flow of blood and more rapid circulation through the diseased tissue, brought about by the exercise given the muscular tissues of the entire body, through the rapid electrical oscillations or vibrations that are obtained by high frequency and high tension currents. The liver, kidneys and all glandular structures are stimulated to more healthy action. Urinalysis demonstrates the effect upon the kidneys; the urine becomes normal in quantity; the elimination of organic waste products is improved; increased combustion is shown by diminution in the amount of uric acid and increase in the percentage of urea.

The faradic current is to be employed where tonic or stimulating effects are chiefly desired, and with this object it is valuable in the treatment of paralysis, of anæsthesia, or in conditions where the involuntary muscles require to be roused; thus the abdomen and rectum may be faradized for constipation, and the bladder and the uterus for atonic conditions.

Faradization of the skin produces a pricking kind of pain, contraction of the muscular layer of the corium, and changes in the diameter of the blood-vessels. The effects are greater if the skin be dry than if it be moistened; for if it be moist, the largest portion of the electricity is led off into the deeper structures, while if it be dry, the resistance to its passage is very considerable, and the skin itself receives all the electricity.

In faradization of the skin, when employed for its reflex effects, the current should not be strong enough to excite muscular contractions. The effect of faradization on the blood-vessels of the skin is to cause them to at first contract and afterward dilate. This can be well illustrated by applying the faradic brush to the skin. The skin at first becomes

pale and anæmic, due to contraction of the arterioles, which is after a few moments succeeded by hyperæsthesia of the skin, owing to the enlargement of the vessels. The reflex action of faradism is also an important element in the treatment of cerebral paralysis. The sensory nerves carry inward to the central ganglia the electrical impressions made on the periphery. This transmitted peripheral irritation influences the functions and is capable of changing the organic structure of central organs, and should never be forgotten in treating paralysis of central origin.

Faradization applied by large electrodes has less effect on the sensient nerves, and consequently causes less pain than if conveyed by a small electrode. For faradizing muscles of a small surface, or fine nerve-fibers, either for clinical demonstrations or for the purpose of diagnosis, small electrodes should be used for obtaining a decisive result.

The faradic current may be used as: (1) General Faradization, (2) Localized Faradization, (3) The Bipolar Method.

General Faradization.—Beard and Rockwell recommend the following method of applying the electric current in general faradization: The patient should stand or sit with both feet resting on the surface of a large metal electrode, to which the negative pole is attached. The other electrode, the positive, is then to be moved over the various parts of the body, two or three minutes being given to each of the more important regions. The treatment of the back and the whole region of the spine is considered to be extremely important and should be thoroughly carried out, the electrode being slowly moved up and down along the whole length of the back. The most thorough form of application requires that the entire surface of the body should be gone over with some regard to order. Special pains should be taken to avoid the scapulæ, clavicle, ulna, sternum, crest of the ilium, and tibia, inasmuch as these and other bony prominences are very sensitive to the electric current. (Severe pain is caused by the current acting on the nerves of the peri-

osteum, therefore the placing of an electrode on the surface of a bone should be avoided as much as possible.) The object of this method of treatment is to bring every portion of the body, in turn, under the influence of the faradic current, so far as is possible by external applications.

General faradization is especially suitable for cases where a general tonic effect is desired, as in constitutional debility, but more especially in nerve-exhaustion. It is called for in those nervous affections accompanied by loss of body weight, and by muscular flabbiness and feebleness. It is a valuable agent in the treatment of dyspepsia, rheumatism, amenorrhœa, chorea, constitutional anæmia, and other diseases associated with deficient vital energy. General faradization should not be used in cases threatened with paralysis or apoplexy, or those in which a recent attack has occurred. After a course of treatment by this method the appetite is increased, the patient sleeps more soundly, there is an increase in the firmness of the muscles, and an improvement in the general condition of the system.

In applying general faradization (as in all forms of electricity) it is best to begin with a very mild current, and then increase or diminish according to the sensations of the patient; always bearing in mind that certain individuals are more susceptible to the influences of electricity than others, and as soon as the sensation produced becomes unpleasant the power of the current should be diminished. The sensations felt by the patient should be of an agreeable nature, a pleasant thrill, without any sort of pain or discomfort. The duration of a treatment should be, on an average, about fifteen minutes. The frequency of a treatment will vary in different cases, but, as a rule, they should be given twice a week until twelve or fifteen have been given. Many cases will not require so many, while others will require more.

The electro-thermal bath is a very excellent method of applying general faradization and may be used in any case where this treatment is to be given.

Localized Faradization.—Localized faradization is applied by placing one pole direct to the part to be affected and the other on some indifferent point.

Duchenne proposed two different methods of faradizing the muscles: By localizing the faradic stimulus in the nervous plexuses or branches, which communicate their excitation to the muscles animated by them (indirect muscular faradization); and by directing the current to the muscular tissue itself (direct muscular faradization).

Localized faradization is called for in all kinds of paralysis; also in certain forms of dyspepsia, rheumatism, and lumbago; as a stimulant in cases of constipation, and as a sedative in neuralgias, especially when the fine coil or tension current is used, for the longer and finer the wire the greater is its power for relieving pain; also cases of hysterical hyperæsthesia, when slight pressure increases distress, while firm prolonged pressure lessens it, are relieved by faradism, the galvanic current having very little effect over them.

Bipolar Method.—The bipolar method is the localization of the current by the means of a single electrode carrying both poles, and is practically the application of localized electricity to internal organs—being used chiefly in uterine and pelvic diseases. Currents of quality for muscle effects, and currents of tension as nerve-stimulants or sedative, can both be used to advantage and without causing pain. In internal local faradization the primary current acts with greater vigor than the secondary.

The bipolar electrodes are made with one pole at the extremity and the other separated from it by an interval of an inch or so of insulating material, so that the current has to go through the tissues to get from one pole to the other. Always connect the positive pole with the internal half of the electrode (the tip), and connect the outer half with the negative. There is no variation from this rule in the use of the vaginal bipolar faradic electrode.

In employing a vaginal bipolar electrode, care must be

observed to keep the electrode as near as possible in the center of the pelvic cavity, and thus avoid influencing the large nerves on either side of the pelvic cavity which, if brought in contact with the tip of the electrode, causes a tingling sensation even down to the toes, and also causing the muscles of the leg to contract violently.

The advantage claimed by Apostoli for the bipolar method in internal applications are: (1) That it is more simple, requiring no assistant; (2) that it is less painful, the sensitive skin being avoided; (3) that it is more active, as localizing the full effect of the current used upon one small point; (4) that it is more efficient, as it admits of the use of stronger currents by reason of the lessened sensibility. The conditions calling for bipolar faradization will be given when considering the electrical treatment for "Diseases of Women."

GALVANO-FARADIZATION.

In this method the battery is so arranged that the two currents (galvanic and faradic) may be utilized at the same time at the same electrodes.

The "combined current" (galvano-faradic) is chiefly of service in overcoming the trophic disturbances which manifest themselves in connection with motor paralysis.

STATIC ELECTRICITY.

Franklinism.

Static comes from the Latin word *sto*—to stand. It was so called because it was thought that this form of electricity stood still on any insulated surface. This form of electricity is also known as "franklinism," so called in honor of Benjamin Franklin, one of the earliest to thoroughly investigate and to give prominence to it; also termed "frictional," because produced by friction.

Static electricity was given to medicine about the year 1750. It was brought to America by Benjamin Franklin

about 1752. The modern Holtz induction machine is the representative source of static electricity to-day. From the early literature we find that Benjamin Franklin used static electricity for medical purposes; later John Wesley used the same current extensively and treated large numbers successfully. During the latter part of the century (1700) Cavallo experimented largely and published all that was known at that time upon the subject. From 1840 to 1850 it was used with great success in Guy's Hospital, London, by men of high standing. From this time up to 1884 very little use was made of this current in medicine. In the work upon

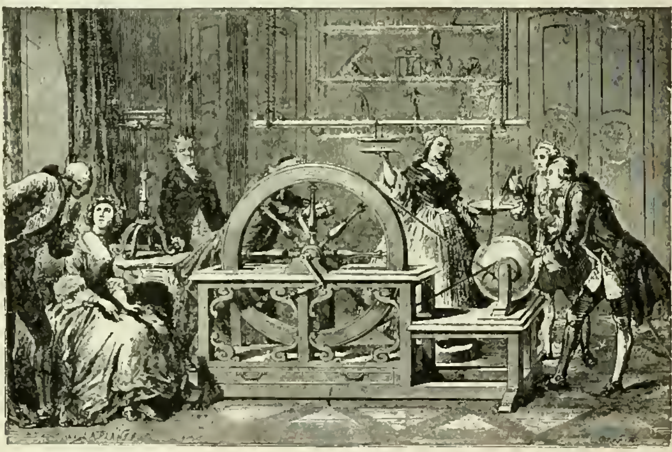


FIG. 3.—THE FIRST STATIC ELECTRICAL MACHINE. A ball of sulphur was cast and mounted upon a revolving axis in a wooden frame and excited by an application of the hands; the assistant so doing becoming the conductor for the positive current to escape. This primitive affair gave feeble sparks, which could only be seen in total darkness. Hawksbee later substituted a globe of glass for the ball of sulphur and collected the positive electricity upon a conductor suspended by silken cords from the ceiling, thereby obtaining more satisfactory sparks with the positive electricity thus generated.

medical electricity by Erb, published in this country in 1883, we find the following: "Experiments, even the latest ones in Paris, have furnished no satisfactory results, and static electricity has still to conquer a secure place in electro-

therapeutics." Within the past ten years static electricity has, as all electro-therapeutists must admit, conquered and secured a place in electro-therapeutics.

The charge has been brought against static electricity that

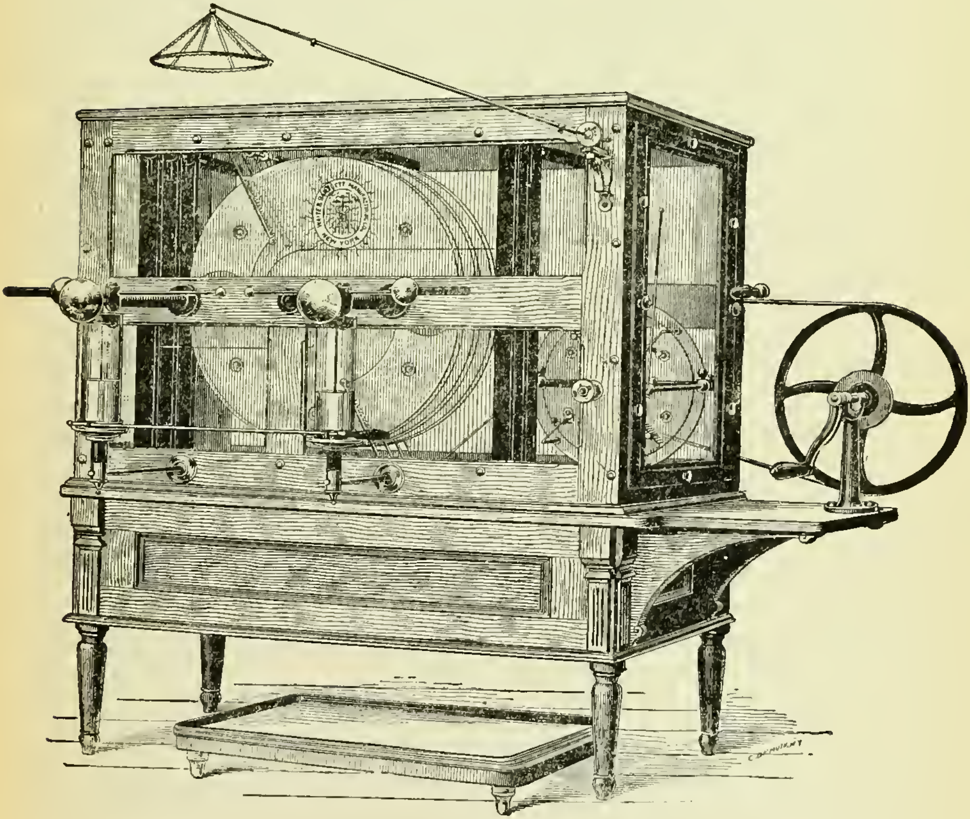


FIG. 4.—THE LATEST STATIC MACHINE. This machine contains within its case a small Wimhurst charger. When the large machine loses its charge (which so frequently occurs in warm, humid weather), it can quickly be restored by a few turns of the wheel, setting the small charger in motion, thereby saving the trouble of opening the doors of the battery and drying the plates or obtaining a charge by friction on the plates with the catskin.

it resides upon the surface of charged bodies, that its influence is superficial, and that it cannot affect deeper parts. Professor Norton has pointed out that not only is this state-

ment disproven by actual experiment, but that it is untenable in the light of electro-therapeutics; that static electricity, when put to medical use, becomes kinetic (dynamic or current) electricity. Its strain is dissipated along and within conductors (the human tissue, for instance) with the same facility as currents having a different ratio of electromotive force or amperes. In other words, a static charge in the act of discharge becomes kinetic, current or flowing, and traverses the human body as it would any other conductor.

Whenever a spark is administered, or the breeze applied, it becomes flowing or current electricity; also when it escapes from the patient, as in the static electric bath or static insulation.

On this point Professor Morton says: "I believe that no form of electricity 'penetrates' more deeply than the static; and premising a powerful machine. a powerful spark, a conservative expectation as to results, a fair comparison with galvanism and faradism, an intelligent selection of cases, and a fair amount of skill in administration, I believe that no form of electricity equals it in curative effect."

That static electricity affects such deep parts of the body as the interior of large joints, the ovaries, and deep-seated muscles, when diseased, thousands of cases on record from good and reliable observers prove to be a fact.

There are many serious objections to the static machine—namely, its expense, the size, and the care that has to be bestowed upon it; but all these objections are overbalanced by the great benefit derived from a judicious use of its current. Owing to its size, it is an instrument that can only be made use of in office practice. A machine to be of any therapeutical use must be able to generate a spark not only of length but also of quantity. The small machines are practically of little benefit in the treatment of disease.

One disadvantage of the large machines is that they lose their charge in damp weather, especially during the spring and summer months. Glass has a great power of condensing

a thin film of moisture on the surface, and this film of water has conducting power enough to discharge any charged conductor. This tendency of the plates to lose their charge may be partially obviated by so placing the machine that the sun will shine upon the glass plates at least for a portion of the day; also by placing chloride of calcium (not the chloride of lime, for that will ruin the battery) in small dishes within the case, and as soon as sufficient fluid appears in the bottom of the dish to become perceptible it should be removed. Calcium chloride possesses the property of depriving the air within the case of its moisture. During the winter months it is not absolutely necessary to keep calcium chloride in the case, but usually it is better to do so. By placing the solution and the moist lumps of calcium chloride in a metal pan in an oven and baking it can be used time and again.

If the battery has lost its charge, it may be regained by heating a catskin, and, immediately on the battery being set in motion, applying the catskin to the plate which has the buttons on, as close above the comb as it is possible to hold it. This rarely fails to elicit a charge. But the easiest and most convenient method of obtaining a charge, and one that rarely fails, is to use a small Wimshurst machine. This can be set on top of the large battery and its poles connected to those of the larger by means of chains. After the large battery is set in motion, a few turns of the wheels of the small battery will immediately charge the plates of the large battery. A small Wimshurst battery seldom, if ever, fails to pick up a charge, no matter what kind of weather prevails. All modern Holtz machines have a small charger within the case which is attached by means of a switch to the belt which turns the large plates, and when the large plates lose their charge it is soon restored by setting the small machine in motion, and the large machine is ready for use every day in the year, and will give a current in all conditions of atmospheric surroundings.

When the machine is not in action the poles should always be left some distance apart. If they are short-circuited by being placed in contact after the machine is stopped it tends to cause a discharge and require recharging the next time a patient is treated, although the state of the weather will affect this somewhat. The machine should be kept in as dry a place as possible to obtain the most advantageous results from its operation. The entire case, metal parts, electrodes, rod and chains should be kept scrupulously clean. Particles of dust attract the electrical output of the machine and waste the current. The metallic parts should be kept bright with a roughed chamois; the electrodes should be similarly treated.

The platform upon which the patient is to be insulated should be near the center of the room, so as to be as far away as possible from the walls and from all objects, as desks, furniture, etc., as they will attract the current from the patient; also the platform should not be placed directly under a chandelier for the same reason.

Care must be observed by the operator not to come so near an electrified patient as to attract the current from the patient in the form of a spark; also, that friends of the patient do not attempt to shake hands with them or receive any article, as a watch, pocket book, etc., as so frequently occurs, they not knowing what the result will be.

The platform end of the rod should come in contact with a chain or metal foot-piece, not allowed to simply rest on the wooden surface of the platform. A wooden surface is a poor conductor, and a great deal of resistance must be overcome before the current reaches the patient. It is obvious that by this manner of placing the rod the patient will receive a very weak current and only a small part of the actual output of the machine. The best method is to have a metallic foot-piece (a brass plate, 8 x 12 inches), and attach to this a brass chain which can be thrown over the end of the rod. Another method is to have the patient hold the rod in the hand.

These methods greatly increase the intensity of the current. Care should be observed in hooking the rod on the prime conductor to always have the ball extremity uppermost, for if hooked on with the ball pointing downward and backward it allows a leakage of the current; also hook the rod as close to the large ball as possible.

Occasionally during the summer months, when the weather is hot and close, and the air is filled with moisture, it will be impossible to get a spark more than an inch long, for the reason that the atmosphere has become a good conductor and the current is induced into the air. Within an hour or two of that time a spark six or eight inches long may be obtained easily, owing to the changes that have taken place in the atmosphere during that time.

Many physicians who understand the care which must be used in selecting the pole in galvanic electricity pay no attention whatever to the subject in using static electricity, because the results are not so immediately discernible, although the difference is just as radical. Until a static machine is started we cannot tell which terminal will be positive or which negative. A pole may be *positive* at one sitting and at the next *negative.* Therefore; before each treatment the polarity will have to be tested. To test the polarity:

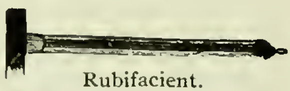
As will be seen from an inspection of a Holtz machine, there are sets of "combs" or "collectors" on each side of the revolving glass disks. If we operate the machine in the dark we will notice that at those combs opposite one of the prime conductors there will be a brilliant "brush light" discharge extending from the combs along the surface of the glass. This "brush" discharge is *positive* and is very different from the discharge at the negative combs which appears in the form of bright star-like points of light. That prime conductor which is an extension of the positive combs will be, by induction, a negative pole; in like manner the other prime conductor will be, by induction, a positive pole.

With a small machine and a moderate current the follow-

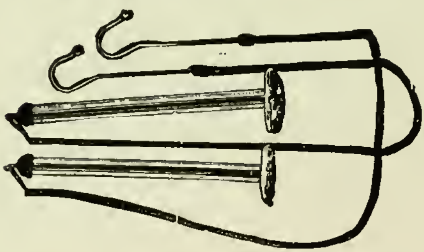
ing test will prove satisfactory, but with a powerful machine and a strong current it will not always answer the purpose: No current will follow down from the head of a match when placed on the negative pole, but will follow down the match, as indicated by the body of the match appearing bright and luminous, when the head of the match is applied to the positive pole.

As regards the detection of the polarity by means of the

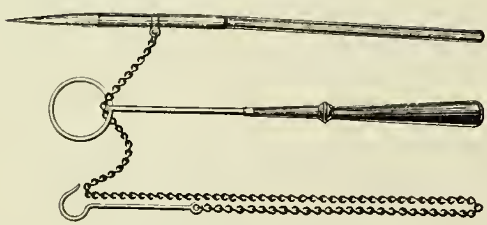
Massage Roller.



Rubifacient.



Handles and Sponges.



Chain-holder and Chain.

FIG. 5.—SHOWING ELECTRODES EMPLOYED IN GIVING STATIC ELECTRICITY.

crimson and white lights appearing at the different poles, a word of explanation is required. Formerly it was claimed that the crimson light always appears at the positive, and the white light at the negative. The lights will vary according to the size of the machine employed and to the distance the poles are separated from each other. In the smaller machines the white light will always be found at the negative and the crimson at the positive pole; but in the large powerful machines, the lights will vary according to the width of the

Brass Balls.

Brass Brush.

Wood Ball.

Wood Point.

Carbon Electrode.

FIG. 6.—SHOWING ELECTRODES EMPLOYED IN GIVING STATIC ELECTRICITY.

poles. When the poles are separated from one-fourth to one-half inch, a white bead-like light will appear at the negative pole, and a diffuse crimson light at the positive. When the poles are separated three or four inches, and with the spark stream in full and continuous action, the spark stream will be seen to be of a violet tint for nearly half its length at one end and bright at the other end. The violet tint shows the

negative pole, the white light shows the positive pole. When the poles are separated four or five inches or more, then the sparks extending out from the positive pole are crimson and those from the negative are white. On account of this variation of the lights in different batteries and according to the width of the poles this test should be discarded and the following test which is very simple, easily performed, and always reliable, should be employed:

If a pointed instrument (a pin answers all purposes), is held between the balls of the sliding poles, the poles being separated several inches, on the point which points toward the positive pole a luminous star-like light will form, and unless the current is exceedingly powerful no sparks will pass from this point to the ball. If the pin is then reversed it will be seen that a stream of fine white sparks will pass from its point to the ball—the negative pole. Place the pin or other pointed instrument transversely at the end of a stick, for if the operator held the pin in his fingers he would be very liable to receive a shock.

In static electricity the voltage is enormous (one million), while the amperage is infinitesimally small, and when we come to consider the fact that it requires about 50,000 volts pressure to force a spark across one inch of air space the tremendous potential energy of static machines becomes apparent, for they are often capable of giving a ten or twelve inch spark.

Of late years static electricity has come more and more into use, and in a great measure has superseded the galvanic and faradic currents in the treatment of nervous affections. It has the advantage that it can be applied to all parts of the body without the necessity of removing or disarranging the clothing—an impossibility with the other forms of electricity.

Static electricity is of far greater value than faradism, and at least as useful, if not more so than galvanism. When galvanism and faradism have either given negative results or have lost apparently for a time their remedial power when

their use has been too long continued, the static form will often be found to possess a decided advantage, and will often greatly aid us in accelerating results.

The static electrical machine is now used to procure all of the nerve and muscular effects hitherto obtained by faradic electricity, and also therapeutic results of a very striking kind of its own.

Endowed with high potential, and extremely small volume, the physiological effects of static electricity are chiefly modifications of the ordinary vital processes without electrolytic alterations. It may increase, diminish, arrest or otherwise modify these functional processes. It affects secretion, excretion, absorption, reflex action, sleep, respiration, circulation and nutrition. Owing to its enormous electro-motive force and its power of condensation and accumulation, it possesses great diffusiveness, which enables it to affect the entire system in a limited degree.

It sets free the potential energy of the cells of the human organism. That is, it excites the cell in such a way that its inherent energy is liberated. It causes contraction of the protoplasm; it excites nerve fibers, nerve cells, and nerve centers; all of them are excited to functional action and caused to produce their separate effects—motor, sensory, special nerve, secretory, sympathetic and vaso-motor. It promotes nutrition of every part it excites, produces marked local and general circulatory effects, and stimulates the vaso-motor nervous system.

In this agent we possess one of the greatest stimulants to metabolism. It is doubtful whether either of the other forms of this force (electricity) can be compared with static electricity as a metabolite.

Metabolism is the sum total of chemical exchanges that take place to constitute life. If oxidation is good, we have certain waste products. If oxidation is not good, we have other deleterious waste products, like uric acid. If uric acid is increased, we have uric acid diathesis. Static electricity

increases combustion, diminishes uric acid and increases urea. Examine the urine of those suffering from mal-nutrition before giving electricity, and after giving it, and you will find the urea increased and the uric acid diminished. Thus you give static electricity for mal-nutrition, and cure a large number of patients. Electricity is a general agent for producing general changes in mal-nutrition.

The vaso-motor nervous system is also strongly influenced. After an experiment upon the human organism with these currents has been long enough continued, there can be seen upon the cutaneous surface dilated capillary vessels and the skin is found to be covered with perspiration.

When an organ is wholly inactive, as in the case of a paralyzed muscle, the amount of blood and the nutritive exchange of fluid is diminished within that part. Thus thrown out of activity, it becomes pale and relaxed, and in the end undergoes fatty degeneration. If cells are imperfectly deprived of their detritus they do not take up oxygen readily, consequently are not adequately nourished and undergo degenerative changes. By the judicious use of static electricity muscular tissue can be brought into activity to a degree to influence circulatory changes, and the cells can be stimulated into action and thus be made to resume their nutritional function.

Static electricity may increase, diminish, arrest or otherwise modify the ordinary vital processes without causing electrolytic alterations, and while it produces no chemical effect in the tissues yet it will increase the circulation, improve nutrition, assist digestion and assimilation, promote absorption and quiet, refresh and invigorate the nervous system.

Without doubt static electricity is the ideal cutaneous stimulant. Every localized application of static electricity in any form tends to stimulate the normal function of the part, and this form of stimulation can be extended over the general surface of the body to influence the functions and

nutrition of the whole system. Its reflex actions are all the more pronounced because of the fact that every local application is accompanied by an impression for good upon the general system.

In cases of mal-nutrition it is an excellent tonic. In fact, it is one of the best general tonics we possess, and as such is easy and agreeable of application, and can be used in a great variety of cases. Devoid as it is of electrolytic action, the power of static electricity seems to be chiefly manifested as a regulator of functions. It excites nerve fibers, nerve cells, and nerve centers.

Static electricity's great fields are *nervous* and *functional* conditions; it is above all things a regulator of the functions and a dispenser of equilibrium. It is a great dispenser of equilibrium to the disturbed balance of the system; it increases the vital forces and augments the energy of absorption. In a word, it excites and facilitates the play of all the functions.

Static electricity is a powerful tonic, having the two-fold action of a *stimulant* and a *sedative*, according to the pole used. It is unquestionably a powerful stimulant to processes of nutrition, and favors the restoration of healthy nutrition in tissues whose vitality has become impaired. In all the realm of medicine there is no single agent so effective. It affords the most certain and permanent relief in all forms of painful muscular affections. To no other treatment do neuralgia, neurasthenia, insomnia, all neurotic conditions and depressed functions so speedily and permanently yield. As a general tonic and stimulant to debilitated conditions, and the infirmities of old age, it is without a rival. In fact, there are but few diseases or conditions in which static electricity cannot be used with beneficent results. There is no remedy more swift in its action, and none more easily applied, and under whatever condition it is used it is ever ready to lend its aid to the restoration of normal and healthy function.

It is our most valuable agent in the treatment of that class

of ailments known as "functional nervous diseases," such as epilepsy, hysteria, chorea, nervous exhaustion, spinal irritation, etc. The various forms of headache and backache will receive great benefit from this form of electricity; also, chronic rheumatism, neuralgia, sciatica, paralysis, and general weakness.

In anæsthesia, hyperæsthesia and spasm, static electricity acts by modifying the conditions of the sentient nerves of the part submitted to its influence. It relieves cutaneous anæsthesia more quickly than either galvanism or faradism. Neuralgias and obstinate headaches usually receive more benefit from this form of electricity than from any other form of treatment.

In static electricity we have a wide range of vibration, from a few up to many millions per second, and as long as the patient comes within this area of oscillation each nerve is taking the vibration which suits it, which would account, in a measure, for the almost magical results we sometimes have in certain forms of neuralgia, migrain, etc.

So nearly certain is electricity in some form to relieve an idiopathic neuralgia that if proper electro-therapy fails time will usually show a severe pathological condition to exist in the vicinity of the nerves, as, for instance, neoplasm, an abscess, or some severe general ailment as diabetes.

Local pain and trophic changes are often very persistent and stubborn in yielding to the electric current and at times they are entirely refractory for a longer or shorter period, and in some cases the current must be applied locally by contact with the electrodes, for general electrization by any form of current must be localized to the seat of local pain.

It is, as a rule, successful with facial neuralgia and generally relieves it in two or three applications, and by continuing it it almost always effects a permanent cure, even in those cases of several years' standing and which have rarely left the patient free from pain for a single day; and which have resisted all forms of medication.

In cord diseases it affords relief from various forms of pain, even when lesions are advanced beyond cure. In the treatment of chronic headache it is of great importance to use caution (as to dosage or quantity given) at first; otherwise the trouble is very apt to be aggravated instead of being improved.

As a rule, static electricity surpasses all other forms of electricity in the treatment of contracted, or paralytic muscles, wasting muscles, acute and chronic muscular deformities, and muscular spasms. Oft-times where no muscular contractions can be obtained in paralyzed muscles by faradism (the galvanic current giving contraction with the anodal closure, thus indicating reaction of degeneration) contraction can be obtained by means of the static current.

Static electricity is of great utility in inducing muscular contractions, and is generally less painful than the strong faradic or galvanic shocks. It is more powerful than faradism in rousing the dormant nerve-centers. It is a valuable agent in the treatment of motor-paralysis, and frequently restores the motor power of the muscles after all other measures have failed. In fact, muscles that have entirely lost their contractility may have it restored to them by this agent. It possesses a decided advantage in some cases where faradization or galvanization have either given negative results or have apparently lost their remedial power after their use has been too long continued.

In hemiplegia and paraplegia depending upon the direct influence of cold or arising from atony and hysteria, static electricity will prove a valuable agent. In estimating the value of static electricity in all cases of paralysis, it must be remembered that its sphere of action relates chiefly to its influence upon functions, and that it is not possessed of properties which will supply new nerve cells, remove a cerebral clot, repair the ravages of a chronic inflammation, cut down excessive formation of connective tissue, or prevent mechanical pressure upon vital structures.

There is nothing more certain in therapeutics than the absolute relief to all forms of muscular rheumatism afforded by electrical currents, and the simplest and most effective current to apply is usually the static.

Cases of chorea will receive greater and more prompt benefit from static electricity than any other form of current. It is efficient in some cases alone, and when rheumatism complicates the chorea it is more than ever indicated. The average results of medical treatment of chorea will be made more certain, more quickly attained, with an early and decided marked relief to the patient's nerve tension, and decided improvement in general health, when static electricity is employed in conjunction with the use of the indicated remedy.

Neurasthenic patients will invariably receive benefit from statical treatments. Their general system will be toned up, and there will be a steady and gradual improvement in all their nervous symptoms. The constipation from which neurasthenic patients in common with many others suffer is almost invariably relieved by the static treatment; the relief resulting in consequence of improved nutrition. The nutrition of the whole cannot be established without the nutrition of a part. Disease is arrested, modified, or cured by curing the patient.

In genuine cases of hysteria with paralysis, aphonia, ovarian pains, backaches, joint pains, curious sensations, and all the vagaries which this neurosis may present, static electricity is the sheet-anchor. It should be applied as a bath with revulsion over the spine and painful points. The cutaneous sensibility to the static sparks, which is found to be abolished or more or less diminished in hysterical patients who are commencing electrical treatment, can be more or less completely restored under the influence of franklinization alone; this can therefore be used as a supplementary aid in diagnosis.

Static electricity has a beneficial action on mental affections, especially in their early stages. Many cases of mental

disturbance leading to insanity, may if recognized in time, be treated and cured by this agent, and the outbreak of the fully developed disease thereby avoided. When the disturbing mental symptoms are dependent upon some physical disease of a curable nature, and more especially if they are the result of worry, overwork, excitement, grief, or long-continued loss of sleep, the beneficial action of static electricity is pronounced. It will assist in clearing up the mind, in soothing and reinvigorating it, and in re-establishing its normal workings, especially when these are impaired by purely functional derangements. In exerting its influence in regulating the functions of mind and body into normal methods of action, its beneficial effects are accomplished without any of the drawbacks attendant upon the immoderate use of hypnotics, sedatives, stimulants and motor depressants.

The first manifest results of this treatment are a quickening of the pulse rate, a flushing of the surface, and a stimulation of the excretory function of the skin; then follows an improvement in nutrition, a brightening of the mental faculties, and improvement in appetite, increase in weight and regularity of sleep.

In hypochondria, melancholia, and in many other functional conditions, it will be found that the temperature is sub-normal; give static electricity fifteen minutes and the temperature will usually become normal.

No other form of electrical treatment will work such marked and lasting benefit in all forms of depression of the general and, especially, of the nervous system, as will the static; and this is the case whether the depression is of the bodily or mental spheres, a single treatment will quiet an overexcited nervous system, and tone up an exhausted body in a manner which cannot be understood except by actual observation.

When the condition of malaise, languor, and immobility to exert the faculties in any desired work is due to temporary functional derangement, it is removable in a few moments

time more certainly and permanently by static electricity than by any other medical means.

In old people the vital forces are lower and all the organs functionate indifferently and imperfectly. Static electricity agrees well with such cases and will often restore the appetite, sleep and physical energy which seemed to have left them forever.

In the convalescence which follows long sickness, such as typhoid fever, etc., the vital force and harmonious action of all the functions are speedily restored by static electricity.

In incurable cases of phthisis, static electricity will often afford temporary benefit by means of its constitutional effects. It is possible by this means to relieve many of the severe symptoms attendant upon advanced cases. The hectic fever, the night sweats, the weak heart action and the cough will be relieved and the temperature lessened—all tending for the time being to make the sufferer more comfortable.

When the patient is anemic and weak, complains of a general coldness, or of habitual cold extremities or other marked circulatory disturbances, positive static insulation with a mild application of negative sparks to the extremities and negative spray to the spine will give more benefit than by any other one measure.

Static electricity, when properly applied, is one of the most powerful stimulants to the nervous system. Its tonic action makes it a valuable agent in diseases of the heart, both functional and organic. As a remedial agent with a marked tendency to regulate and sustain the normal functions of the body, static electricity becomes one of the best of heart tonics and is probably the very best extra-drug therapeutic measure in both functional and organic diseases of the heart.

Both in pulse and temperature, static electricity produces an equilibrium; that is, if the pulse is below normal, a static treatment will raise it up to normal; or, if above normal, it will reduce; the same is true of the temperature.

Static electricity is a tonic of great efficacy and useful in a

wide range of cases, sub-acute or chronic, where a stimulating or tonic effect is desired. It cures certain diseases by changing the electrical condition of the patient, which may be rendered positive or negative at will.

Static electricity, by equalizing the nervo-electric force of the system, causes unhealthy action to be changed to healthy; and thus health may be restored. It acts to agitate and change the nutrition of the tissue—is a powerful alterative.

In all vasomotor disturbances, functional cerebro-spinal diseases or neuroses, there is nothing which equals in value the diffuse and the concentrated constant high potential current from electro-static induction machines. It quickens the circulation and promotes the glandular secretions and insensible perspiration; metabolism is promoted, appetite and digestion are improved, circulation and nutrition are benefited, sleep is notably restored, and nerve-vigor is imparted to the mental and physical faculties.

One of the most important points in the use of static electricity is the necessity for caution in order to avoid giving too large a dose. The great test for the dose of electricity to be given in any case is the nerves; and the best indication of their condition is the sleep. If the patient sleeps well every night, it is a pretty good indication that the dose he is receiving, even if a large one, is not causing irritation of the general nervous system.

The different effects that can be produced, according as the spark, the douche, or breeze, or simple insulation is employed, render it a very valuable agent. It can be even converted into the dynamic variety (static induced current) with effects similar to that of the faradic current.

METHODS OF APPLICATION OF STATIC ELECTRICITY.

There are several different modes or forms of applying static electricity to a patient, and each form has its special indications.

The modes are: Static insulation, or the static "electric

bath;" static sparks; shocks with Leyden jar discharge; direct statical head breeze; static massage; and, the static induced current.

STATIC INSULATION; OR, STATIC "ELECTRIC BATH."

In this form of application the patient sits upon the stool, which in turn rests upon an insulated platform. One pole of the machine is attached to the platform, while the other is grounded by a chain running to the floor, a water-pipe, or a gas-fixture.

The poles of the machine are separated as widely as possible before the battery is set in motion. The patient is charged positively or negatively, according to whichever pole he is connected with. The current flows gently and silently into the patient, saturating the whole system and escaping into the air from the various prominent points of the body. The escaping of the electricity is particularly noticeable in reference to the hair; every hair, providing it is not damp or oiled, standing out straight from the head. If the electric bath be given in a dark room, luminous appearances are produced by this escape of electricity into the air, especially about the hair. Complete electrification is shown by the loose hairs on the patient's head, which stand tensely out in all directions.

This form is the most agreeable of all the methods of static treatment, is absolutely free from shock or disagreeable sensation, and is adapted to the most sensitive and delicate conditions. Immediately upon the battery being set in motion, the patient's hair begins to rise, and in a few moments a very pleasant sensation is felt through the system.

The electricity enters and leaves the body painlessly, slight tingling of the surface is experienced, face becomes flushed, hair erect, action of heart accelerated, and in a few moments a general perspiration breaks out. Patients, after being elec-

trized in this manner, often describe a sense of increased energy and a sense of exhilaration. The static bath has the great convenience that it does not require the removal of the clothing, as does the water bath.

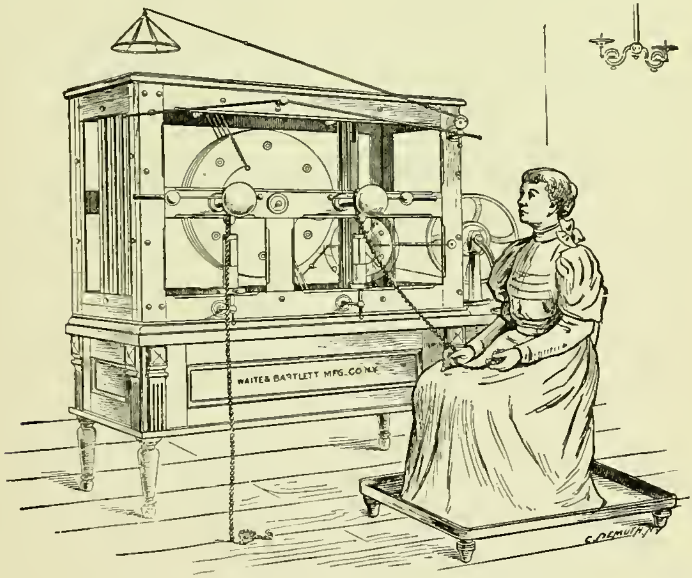


FIG. 7.—SHOWING METHOD OF GIVING STATIC INSULATION, OR THE STATIC ELECTRIC BATH.

The "bath" of static electricity, when the positive pole is attached, is a most powerful stimulating tonic, and, when attached to the negative pole, a sedative tonic.

There is a marked difference in the sensation between the two poles: When insulated positively the sensation is as though you were overcharged and the electricity was forcing itself out—a sensation as though you could feel the current issuing from every part of the body and even from every pore of the skin; while with the negative charge you feel the hair raise, but none of the marked sensations as experienced with the positive insulation. This is due to the higher voltage of the positive pole. When a patient is seated upon the platform and charged from the negative prime conductor the dif-

ference of potential between the charge and zero is very much less than the difference of potential between the positive charge and zero.

In dry, cold weather care should be observed when positive insulation is being employed. It is often the case that in a high positive insulation sparks will jump between the metal parts within the case, thus causing some shock (but more alarm) to the patient. This can be done by reducing the speed of the machine.

During an electro-positive bath the whole surface of a patient's body becomes charged with positive electricity, while the air surrounding it is rendered negative; thus, by changing the electric condition of the body, the patient's general conditions are improved, and many diseases are cured.

The state of the electrification of human bodies in normal health is almost invariably found to be positive; hence the beneficial results of positive static insulation. If bodies in low states of health are found to be negatively charged, then the positive charge (which is the rule in health) derived from the static machine is in the nature of a change of climate, and in fact is quite often as beneficial.

Static insulation, when applied with the positive pole, is a refreshing, grateful, and most agreeable tonic in all debilitated or negative states of the system—those neurasthenic, anæmic, malarious, cachectic conditions in which the patient is "below par."

The atmosphere surrounding a patient seated upon the insulated platform of a static machine is richly charged with ozone, which the electrical action rapidly generates, and which, inhaled by the patient during treatment, no doubt contributes to the beneficial results.

The conditions calling for "positive" or "negative" insulation are best studied with reference to Cases No. 1 and No. 2 in the diagrams which follow. The first column gives the morbid conditions from which the patients are suffering

the second column gives the special method of applying static electricity to each set of conditions:

CASE I.	Congestive headaches. Insomnia. Cold extremities. Nervous excitability.	Negative insulation, 10 minutes. Positive head breeze, 5 minutes. Positive spinal breeze, 5 minutes.
CASE II.	Anæmic headaches. General anæmia. General muscular weakness. Nervous exhaustion.	Positive insulation, 10 minutes. Negative head breeze, 5 minutes. Negative spinal breeze, 5 minutes.

The static bath increases the metabolic exchanges, causing an increase in the amount of oxygen consumed, as evidenced by the increased pulse, the elevation of temperature (sometimes a degree or more), and the increase of urea excreted. During the treatment the secretions, especially perspiration, become more active; the skin, if the administration is long continued, breaking out in a mild perspiration. The temperature is slightly raised, if subnormal; the pulse is slowed, if fast, and there is often a feeling of warmth similar to the pleasant reaction after a bath.

One of the beneficial results obtained from the judicious use of the static current is relief from insomnia. Positive insulation for ten minutes followed by a strong negative spray upon the entire spine, and especially concentrated upon the cervical, cerebellar and lumbar centers.

Neuralgia of the stomach can be greatly benefited, and in the majority of cases relieved, by the use of the franklinic current in the form of electro-positive or electro-negative baths, combined with local treatment by drawing sparks from the painful region.

Static insulation is one of the best tonics we possess, and as such is easy and agreeable of application, and can be used in a great variety of cases.

For the after-effects of the "grip," for brain fag of professional men, for physical, mental and nervous exhaustion, it is in the nature of a specific.

Static electrification possesses nutritive and tonic properties of a high order, and in certain conditions one may even succeed in obtaining results after unsuccessful attempts with dynamic electricity.

Static insulation is especially useful in the treatment of "incipient insanity," on account of its great power to strengthen and tone up the depressed nervous system.

Its great fields are nervous and functional conditions. As a general tonic, and also as a stimulant to depressed nervous functions, "static insulation" will surpass any other form of electrical application. In fact, static insulation is the base of all treatment by static electricity.

Far oftener, however, this treatment is passed by and the more severe methods employed. Too often the doctor is desirous of using that form of current (sparks) which makes the greatest impression (sometimes a very painful one) upon the patient, thereby losing the beneficial effects of the treatment. On this point Dr. Caldwell voices what should be the sentiment of every static electro-therapeutist when he says: "In its application to disease, much has been written of the 'static spark' shock, or more severe form of its application, and many fall into the error of believing that, in order to get a pronounced physiological effect, treatment must be severe. If a little is good, more must be better. While in a certain class of diseases the severer methods are both useful and necessary, in others they are entirely needless."

In giving static insulation care must be taken that the patient is well insulated, for if the patient is not well insulated there is a great waste of electricity, and the patient will not receive the full benefit of the "bath." The most perfect insulation is obtained by using a platform of glass having glass supports about twelve inches in length. The patient should be seated in the most comfortable manner possible, and should keep perfectly quiet during the entire treatment, thus placing the nerve force at rest in harmonious action with

the current. After the treatment the patient should lie down for a short time.

STATIC SPARKS.

When the patient sits on an insulated platform, if a brass ball electrode connected to the other pole or to the earth provided the current is grounded, is brought near the patient, a disruptive discharge ensues, accompanied by a spark.* This then converts static into current electricity. The spark is neither taken nor given. It is the composite effect of two electricities; the union is called a spark. The duration of the whole spark has been estimated to be all over in the hundred-thousandth of a second. The short duration of an electric spark produced by a single disruptive discharge is easily made apparent by a rapidly rotating disc, having rapid sectional areas of different colors. With reflected sunlight, the colors seem to blend into one tint upon the principle of persistence of vision; but when viewed by the flash of a spark, the colors are seen as distinctly separated as if the disk was at rest. It was discovered also, by the rotating mirror, that the apparently single spark was composed of several following each other in quick succession. These sparks produce a pricking sensation, and at the points touched slightly raised spots with congested areola, similar to flea-bites, are produced. This eruption usually disappears within an hour or so. Sparks are taken from a patient in two ways, called the *direct* and *indirect* method.

The Direct Sparks.—In this method the patient is placed on an insulated platform, and connected with one pole of the machine (positive or negative, according as to whether posi-

* When the poles are separated lightning-like sparks will jump across from one terminal to the other and appear like a continuous stream, and presenting a zigzag course resembling lightning. In fact, it is a "streak" of lightning in miniature form. Their curious zigzag form is due to the current taking a path through the particles of air having the least resistance. The air is one of the greatest non-conductors there is. There would be little left to electrical science if air was a conductor of electricity.

tive or negative insulation is desired) by means of a chain or brass rod. A chain connected to the other pole is attached to a brass ball electrode, which is brought near the part to which the spark is to be applied or drawn from. The length and strength of the spark is regulated by the distance which the two poles are separated.

The Indirect Sparks.—In this method the patient is seated upon an insulated platform, which is connected to one of the

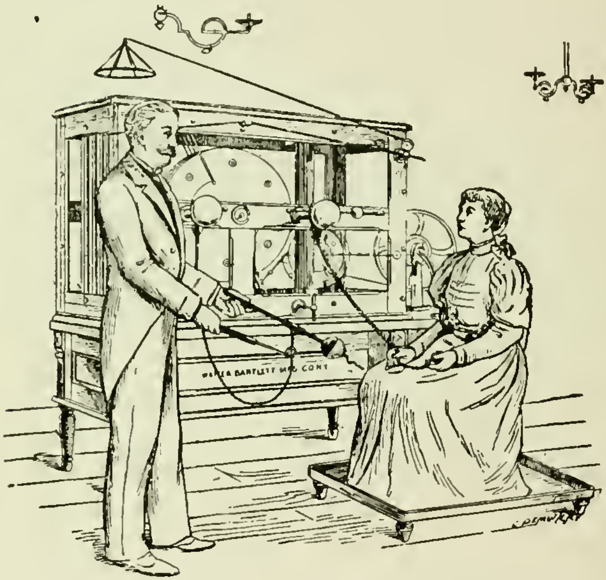


FIG. 8. SHOWING METHOD OF GIVING THE DIRECT STATIC SPARK.

poles of the machine by means of a chain or rod; to the other pole of the machine is attached a chain, which is grounded by being connected with gas or water pipes. An electrode (ball, roller, etc.) is connected to a chain, which is either thrown on the floor or connected with the gas chandelier (providing that the current has been grounded by means of a water pipe), and when the patient is charged the electrode is brought near him, and a spark is immediately seen to pass

between the two. The length and strength of the sparks are regulated by the distance which the poles are separated.

Grounding the machine enlarges the area over which a charge may be distributed before it is discharged by its spark, and practically amounts to the use of large condensers; that is, Leyden jars. It increases the electrical capacity; there is not only a greater charge, but a greater discharge, whether convective or disruptive. The character of the discharge is changed in some instances from an non-oscillatory to an oscil-

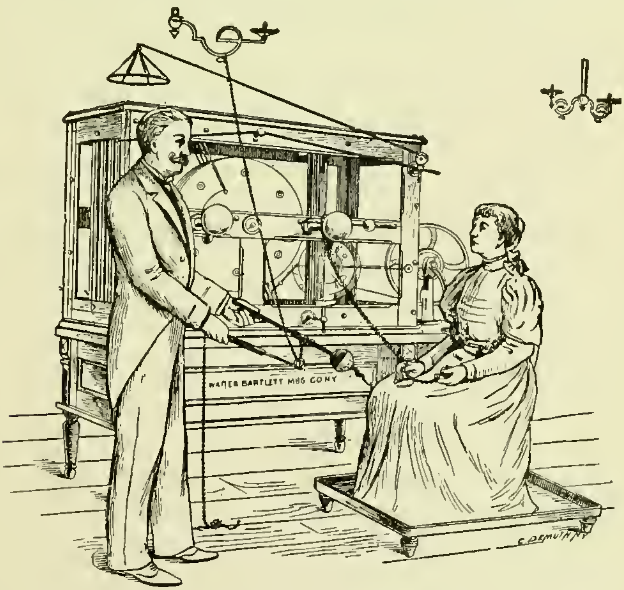


FIG. 9. SHOWING METHOD OF GIVING INDIRECT STATIC SPARKS.

latory one, while in others there is produced a more typical oscillatory discharge. The disruptive discharge thus obtained is vivid, clean and thick and not inclined to break up nor irritate as the spark obtained from the direct method. This is due to the change in the character of the discharge, from a non-oscillatory to an oscillatory one, and in this physical fact is found the reason for gounding our machines for medical work.

Sparks administered by the indirect method are not so severe as by the direct method. When using either the direct or indirect sparks, if a mild form of treatment is desired, or if the treatment is about the head, a wooden ball electrode should be employed.

In using static sparks one has to be careful with very sensitive patients not to begin too violently. Very sensitive patients often respond badly to static sparks when given very strong, and for this reason it is often best with them to begin with a mild spray or breeze and later mild sparks from the pointed electrode instead of the ball. Never apply heavy sparks to a new patient at the first sitting; nor apply them so heavy at any time that the patient goes away thinking that the cure is worse than the disease.

All cases do not require sparks, and when sparks are especially indicated mild ones may often serve the purpose as well as, if not better than, severe applications. Sparks should be no heavier than are needed to do the work. The milder forms should always be tried before resorting to the heavier form.

Some individuals are more susceptible to sparks than others; some will seemingly enjoy the heaviest form of sparks, or at most evince very little pain. In applying static sparks always remember the following points: Apply single, thick, clean sparks directly to the part to be influenced; do not hold the electrode over one part continuously for any length of time, for a number of sparks upon the same spot is apt to create a tenderness; do not apply the sparks here, there and everywhere in an indiscriminate manner; either sweep the electrode quickly across or along the part to be influenced, thereby permitting only a few sparks to jump from its end to the patient. By regulating the sparks in this manner, they are less painful and their physiological action is greater.

Before applying the sparks it is better to have the patient remove his watch, and lay aside keys, eye-glass, etc., for they will attract the sparks and produce too sharp a sensation for

comfort in some cases. The same precautions will have to be observed when administering sparks to ladies who have on their wearing apparel steel buckles, metal buttons, etc. Some fabrics facilitate the application of sparks more than others.

In applying sparks upon the skin, it may be dried perfectly, if desired, by first dusting it with a little powder. The spark is then thicker, cleaner, and less sharp. A long, thin spark is usually stinging, while a thick one is less so. If a spark "splits" and gives off fragments seek the cause and correct it, for such a spark produces an uncomfortable sensation. In administering sparks, care will have to be observed to avoid the bony prominences throughout the body; also the nipple, the dorsal surface of the foot or hand, and especially over a toe- or finger-nail. As a rule, however, sparks should not be applied to the head.

A counter-irritant and stimulating effect is produced by a very quick rubbing of the large brass ball electrode over the surface of the clothing in close contact with the patient. This must be swiftly done or else it will be intolerable. The sensation is as of thousands of hot needles, but if well done is followed by such distinct relief in the average case as to be uncomplainingly submitted to. The positive application is less sharp and hot than the negative.

The spark, by its powerful mechanical disturbance, sets up a great molecular change and acts as a stimulating massage. It thus affects the nutrition of a part, disperses exudated materials, and promotes absorption.

The static sparks of either form excite powerful muscular contractions, and thus constitute a very powerful form of massage. Static sparks of every degree contract muscles to which they are applied, and more powerfully so when they strike the motor point. They excite strong muscular contractions and produce a wide-spread mechanical disturbance in the tissues to which they are applied, causing active molecular change and exerting an extensive influence upon both local and general nutrition.

Regarding the muscular contractions produced by the local sparks as a gross massage of the tissues, it is considered that in the general vibrating administration of a rapidly alternated potential we subject the constituent particles of the tissues to an insensible molecular massage, the benefits of which are apparent in the vasomotor system in better circulation, in increased excretion, in better oxidation, better sleep, more vital energy—in short, in an increased functional stimulation and in general progressive improvement.

The role of muscular activity is one that is well established, and the effect is to produce an increased activity of the blood stream within the muscles of an intact body. The blood-vessels dilate so that the amount of blood flowing from them is increased. At the same time the motor fibers are excited; the vaso-motor fibers are also. Muscular contraction is attended by the production of heat. This is greater or less, according to whether these contractions are many but small, or few and larger. In the latter case more heat is generated. This shows that larger contractions are accompanied by a relatively greater metabolism than small contractions, which is in accord with clinical experience.

We can also use it to secure muscular effects, as at affected areas in spinal cord diseases. In paralysis you can pick out and put in action, if that is possible, each muscle in the body. For paralyzed muscles, the spark fulfills the ideal requirement that the muscles should be stimulated periodically—that is to say, with a brief interval of repose (30 to 60 per minute), in order not to do more harm than good, by establishing physiological fatigue and consequent increased waste in the muscle. The continuous stimulation of nerve or muscle is to be avoided.

The static spark is the most powerful stimulus to nerve and muscle function, and rapidly imparts tonicity, lightness, buoyancy, and firmness to soft, lax, and enfeebled muscular substance. It has given the most brilliant results in the

various forms of paralysis, and frequently restores complete muscular power after all other measures fail.

The application of static sparks to post-paralytic contractures and protracted tonic muscular spasms surpasses every other form of electrical application. Thickening of joints, tendons, and muscles, local œdemas, effusions, etc., are reproduced by strong, thick static sparks.

The various forms of paralysis associated with hysteria generally yield to a few applications of the sparks ; its results in these cases are often miraculous. Cramps in the calves of the legs may be quickly relieved by a mild application of the positive sparks to the parts affected. In muscular rheumatism, and in stiff joints from chronic rheumatism and gout, sparks are withdrawn from the affected parts, with marked relief in many cases.

The static spark, through its action upon the peripheral nerves, produces nutritive changes, not only in the organ to which it is applied, but, by reflex action, through the whole system. Torpid liver, gastralgia, dyspepsia, and constipation have been relieved by drawing sparks from over the affected organs, the action being reflex.

By means of the sparks the internal organs can be influenced reflexly through stimulation of the external peripheral nerves. Every internal organ has an area of skin-innervation which represents it externally, and by applying sparks to this external area the internal organ which it represents is affected.

The principal regions are : the region of the lower angle of the right scapulæ, in diseases of the liver ; a similar area in relation to the left scapulæ, in diseases of the spleen ; the distinct backache and pain across the lower part of the lumbar region, in disease of the uterus or its appendages and in constipation. No matter how far from the local irritation a reflected pain may manifest itself, apply the sparks to the sore place and the impression will track the pain to its seat and drive it out.

The effects which peripheral stimulation exerts upon the central organ play an important part in electrical treatment, and afford the best explanation of the benefit which follows even in cases where the treatment has been applied to the peripheral parts only. In its reflex action it has proven to be strongly tonic, not only to the nerve itself, but to the whole system as well.

By withdrawal of sparks from the various organs of the body, tonic and invigorating effects are obtained in cases of neurasthenia, exhaustion, and debility from various causes.

Static sparks surpass all other forms of electricity in that painful and obstinate affection known as "lumbago." Often one application will be enough to cure it.

Remarkable cures are effected in anæsthesia, hyperæsthesia, and neuralgia by insulation and the withdrawal of sparks from the affected parts. It is especially useful in the various forms of rheumatism, such as muscular rheumatism, gouty rheumatism, etc. Pains, in whatever location found, are often dissipated after a few applications of the sparks.

Anæsthesia, not only of general sensibility, but also of pain and temperature, is more rapidly improved by the static sparks than by either galvanic or faradic applications.

There is no agent or remedy that will so efficiently check the severe stabbing and lightning-like pains of locomotor ataxia as will the static sparks. In spinal cord diseases it affords relief from various forms of pain, even when the lesions are advanced beyond cure.

In chronic and rebellious forms of intercostal neuralgia often a few applications of static sparks will cause them to entirely vanish.

Static sparks applied to "boils" in their earlier stages is almost a specific in checking their further growth—the boil withering and drying up within thirty-six to forty-eight hours.

Sciatica often yields to it more readily and permanently than to any other form of treatment.

In chorea, sparks applied along the spine and to the limbs will give excellent and often brilliant results.

It is both a cutaneous sedative and counter-irritant, and makes a powerful peripheral impression of great value in neurasthenia.

When the function of a nerve is destroyed, it becomes necessary to bring it within the range or subject it to a rate of vibration equal to its own. Every time a spark passes between the prime conductor oscillations are set up, sometimes many millions per second, and these vibrations, when the patient is included in the circuit, are conveyed to the nerves. In health the nerves are all in a state of vibration, and when they lose their vibratory action their function is destroyed and degenerative changes commence; hence the reason why static electricity is especially adapted for the treatment of disturbances of the nervous system.

Often during the summer months it will be impossible to obtain sparks from a patient who has been perspiring freely, owing to the fact that the moisture which fills the clothing conducts the current off before it reaches the body. When this condition exists, the difficulty can be overcome by removing the clothing and drying the skin, afterward laying over it a dry towel. Many times, however, by simply laying a dry towel, or preferably a chamois skin, over the clothing, sparks can be readily obtained.

SHOCK WITH LEYDEN-JAR DISCHARGE.

In this form of treatment, a pair of Leyden jars are attached to the poles of the battery, the tin-foil of each being connected by means of a brass rod. One pole is connected with the insulated platform, and the other to the electrode to be used. Before setting the machine in motion, the poles should be brought together. In using this form of treatment, the sparks, as a rule, should be applied directly over the skin. These sparks produce a sharp, pungent sensation, known as the "electric shock."

The Leyden jar sparks affect more profoundly the deeper tissues of the body than do the direct or indirect sparks. This form of treatment is especially useful in tuberculosis of the knee-joint, or, as it is commonly called, "white swelling." The joint is perceptibly diminished in size after two or three applications, and, if the treatment is persisted with, a radical cure will be obtained.

STATIC BREEZE OR SPRAY.

This method of applying the static current consists in the withdrawal of the static charge from the patient by means of a pointed metal instrument or wood electrode. There are

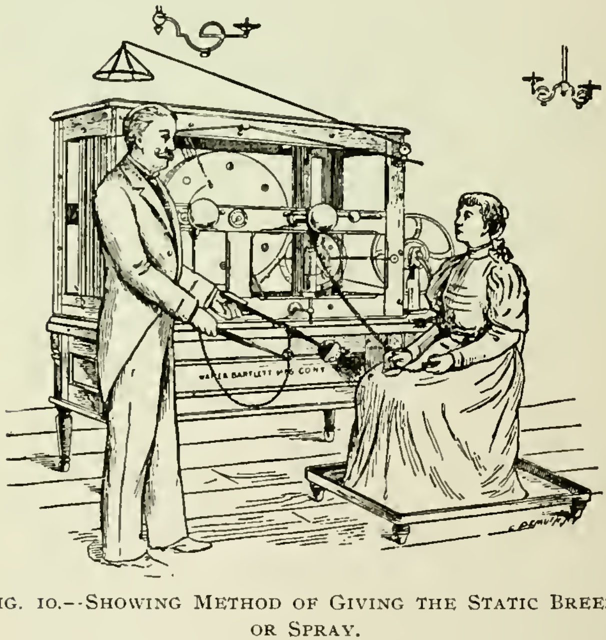


FIG. 10.--SHOWING METHOD OF GIVING THE STATIC BREEZE OR SPRAY.

two methods of application, termed "direct" and "indirect."

In the direct method the patient is seated upon an insulated platform, which is connected with one pole of the battery by means of a chain or rod, and an electrode (brass, wood, or

carbon, as may be desired) is attached by means of a chain to the other pole.

In the indirect method the patient is placed upon an insulated platform, to which one pole is attached, and the other pole being grounded by means of a chain attached to a gas-pipe or water-faucet.

Immediately after the battery is set in motion, the electrode is brought within five or six inches of that portion of the patient's body which we wish to be brought under the influence of the breeze. The patient feels a pleasant sensation, as of a cool draught of wind playing upon the part under treatment. Care should be exercised not to bring the electrode so near to the patient as to produce a spark or shock, which is not only disagreeable, but in some cases injurious.

In either the direct or indirect method, when the breeze is desired to be localized and powerful, the brass-pointed electrode should be used. When, however, a mild current is desired or when the application is made about the head, and more especially about the eyes, a wood-pointed electrode should be used. In warm or damp weather the carbon electrode will frequently be found to be more efficacious than either of the others. The brass-pointed electrode can be made to apply a breeze, frictional sparks (by sweeping the point of the electrode near the patient), or single percussive sparks, with equal effectiveness.

For a stationary breeze upon the head, forehead, occiput, joint, or any localized part of the spine or body, fix the brass-pointed electrode to the stand and set it at a proper distance from the part to be treated. If the electrode is too far away, it not only becomes diffused when it should be concentrated, but loses its soothing character and is exceedingly irritating. The secret of many good effects of the static breeze depends upon concentration of action, and when it is diffused, either by the size of the electrode or the distance at which it is manipulated, the sedative effect is lost.

Care must be observed that the point of the electrode does

not come too near the patient, for it will draw an unexpected spark and thus startle the patient unnecessarily, and if the patient is a very nervous one the chances are that all the benefits of that treatment are lost.

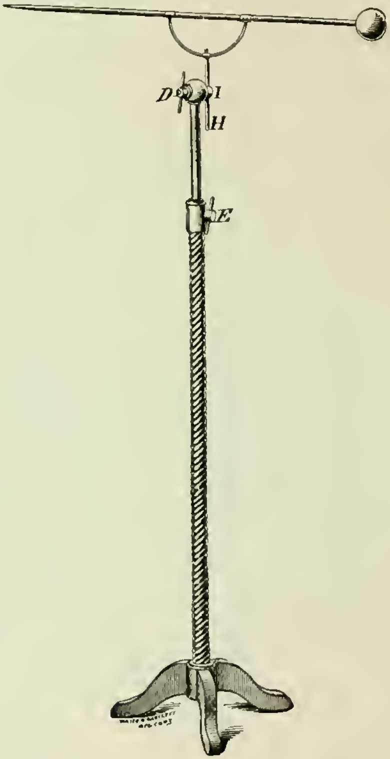


FIG. 11.—REPRESENTS A LONG-POINTED ELECTRODE FOR CONCENTRATING A STACTIC BREEZE. To connect this instrument with the static machine, place it in slot *I* and fasten with screw *D*, by which you can deflect to any angle, and connect with one chain from the battery to *D*, the other from the battery to the platform or floor. To use, deflect the point of electrode to the part to be treated, the poles of the battery being pulled apart according to the strength required. *E*, devise for raising or lowering the electrode.

In applying the spray about the head, care will have to be taken where there are steel hair-pins, as they concentrate the

current and cause a disagreeable sensation. Have all celluloid hair-pins or combs removed, as there is a possibility of them exploding and causing serious damage; also where there are metallic ornaments about the neck, it is better to have them removed.

When the patient is insulated and the spray administered by means of a sharp-pointed metal electrode, a shower of visible electrified particles of air extends from the point of the instrument to the patient. The positive spray is much more marked than the negative. The sensation produced by the spray or breeze is quite pleasant to most patients, the feeling being as of a gentle breeze on the head.

In applying the static spray or breeze care must be observed in selecting the indicated polarity. By positive breeze is meant the application from a grounded positive electrode, the patient being insulated negatively. By negative breeze is meant the application from a grounded negative electrode, the patient being insulated positively. The positive is termed the high potential pole, the negative the low potential.

Positive insulation produces a more active rate of change within the tissues than negative insulation, because the voltage is higher, and more readily overcomes the resistance of the insulating atmosphere and diffuses out of the patient with greater energy. The positive breeze is sedative and the negative stimulating.

One of the most grateful and mild forms of treatment is the positive breeze. It is especially valuable in neuralgias, nervous insomnia, and in nervous and congestive headaches. In headaches of nervous and circulatory irregularities, anæmia, congestion, anxiety, overwork, the satisfactory relief it speedily affords at the first application becomes permanent nearly always after sufficient treatment. In all forms of reflex headache the cause must be removed before marked relief can be expected from its use.

Pains arising from various causes and located in various parts of the body are, as a rule, quickly removed by a gentle

administration of a positive static breeze. In fact, it will relieve almost any type of pain not due to structural change.

When disordered function manifests itself by sore and bruised feelings in the soft parts, the positive static spray restores the normal circulatory state and produces comfort.

If there is soreness in the muscles of the chest; if the muscles are fatigued by coughing; if there are local pains of any character; if there is a sense of constriction or oppression, and the patient is unable to take a deep breath, insulate the patient negatively and apply the positive spray across the chest and along the cervical region of the spine. It is usually possible to relieve the difficult breathing and restore the capacity for deep inhalation within a few minutes.

In those cases of general debility and exhaustion following acute and exhausting diseases, where convalescence is slow, positive insulation followed by negative breeze to spine will hasten the action of the torpid functions and pave the way for a more rapid recovery.

The negative breeze is sharp and stimulating, and may be made irritating to an uncomfortable degree. It is especially valuable in relieving pain from sores, boils, inflamed swellings, muscular rheumatism, lame back, chronic inter-costal neuralgia, and those pains due to gastric and hepatic irritation.

Painful chronic states which are best treated by counter-irritation or muscle-stimulation are well treated by either the concentration of the negative breeze into a strong spray or by short friction sparks from the brass-pointed electrode.

With positive insulation the spray from the brass-pointed negative electrode discharges the patient with a still greater difference of potential, and the increased voltage gives to the spray more pungent, stinging, penetrating, heating, and stimulating properties.

In employing the negative head breeze, the electrode will have to be kept constantly in motion when applied to a scalp which is covered with thick hair or the irritation will be well-nigh intolerable.

Both forms are analgesic and will relieve many varieties of pain. The anodyne effects of the static breeze are not produced by local anæsthesia. They do not benumb. They act so far as they are either temporary, or become permanent by repeated doses, by changing disordered sensations into orderly and normal sensation.

The static current relieves the pains of a toothache and the sore bruised gums following either the filling or the extraction of teeth.

Troublesome coughs due to bronchial or laryngeal irritation from catarrh or chronic inflammation can be quickly relieved, and in many cases cured, by local application of the static spray and free inhalation of the ozone generated at the positive pole of the current.

Static electricity in the form of a breeze, applied to the head, will check permanently falling out of the hair. It is a matter of common observation that patients undergoing a course of treatments with static electricity for some other chronic affections notice that their hair ceases to fall out. This is due to the fact that as the general nutrition has improved, the nutrition of the scalp has also been improved.

In administering the breeze it must be remembered that the positive pole is a sedative, and would be called for in *congestive* headaches; that the negative pole is stimulating, and would be indicated in *anæmic* headaches.

The breeze or spray is the most exquisitely delightful of all electric applications, and is not surpassed in importance by static sparks. In fact, the sparks are too often given for various conditions, when the spray would have served the purpose much better and have been far more pleasant to the patient.

The static breeze when intelligently administered gives most brilliant results in an increase of vital power. It has a decidedly refreshing and soothing effect upon the entire nervous system, and is of great service in nearly all nervous diseases.

DIRECT STATICAL HEAD BREEZE.

This method of applying static electricity is simply a modification of the direct breeze; instead of a sharp-pointed instrument being used, a metal crown with many points is used.

In this application the patient sits upon an insulated platform, which is connected by means of a chain or rod to one of the poles of the battery, the other pole being attached by means of a chain or rod to the brass crown, which is elevated five or six inches above the patient's head.

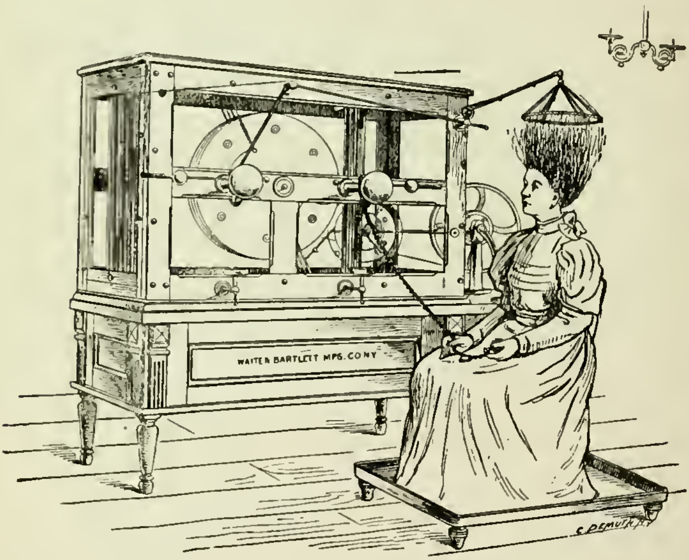


FIG. 12. SHOWING METHOD OF GIVING THE STATIC BREEZE BY MEANS OF A METAL CROWN.

The electric head breeze, or "bath," can be made much stronger by having the patient hold the rod or chain in his bare hand; or, better still, having him rest his feet upon a metal plate or chain that is connected with the rod or chain from the battery. When the battery is put in motion, a pleasant sensation is felt permeating the hair and encircling

the head. If, however, the breeze is concentrated at one point more than another, the patient will feel a prickling sensation, like fine needle-points, over the scalp.

In the static "head bath" the positive pole is sedative, and will be indicated in congestive headache, insomnia, etc.; the negative pole is stimulating, and will be called for in anæmic conditions.

STATIC MASSAGE.

Static massage can be applied in two ways: (1) The patient is seated upon the insulated stool, which is attached to one pole of the battery, the brass roller attached by a chain to the other. The two poles of the battery are then brought near to each other without contact. The battery being set in motion, the roller is passed over the arms, spine and legs, the strength of the current being regulated by the position of the poles; the further apart they are, the stronger the current. (2) The patient may sit on an ordinary chair, with the feet resting upon a large square foot-electrode, connected with one pole of the battery. The massage roller, as in the first application, is attached to the other pole, and is passed over the extremities as well as the body of the patient. It thus produces a multitude of little sparks, whose length is measured by the thickness of the interposed fabrics.

In giving treatment with the roller it is always necessary that there should be an intervening cloth between the surface of the patient's body and the roller. The reason why friction can only be made over the clothing is, that, if the roller were applied directly to the skin, there would be no insulation—the current would be conveyed directly to the earth. In giving the massage treatment the roller exercises a stimulating local action and a distant reflex action, whose effect, on the whole, is sedative; when applied over a large surface of the body, it is distinctly stimulating.

The application of the roller electrode is so similar in principle to massage that it has long been called the massage

roller. The effects of static massage are local and systemic. Following an application of the roller, the vessels dilate and an increased quantity of blood enters them, and thus the motion of the blood current is accelerated. The immediate effects of these changes is to promote the nutritive energy of the tissues subjected to the application. The result is an improved color, warmth and volume of the parts. Following

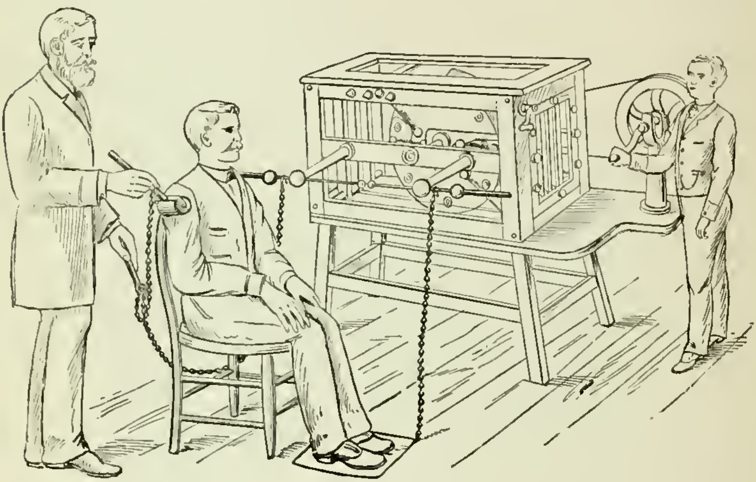


FIG. 13.—SHOWING METHOD OF GIVING STATIC MASSAGE.

a course of treatment, the body increases in weight, all the organic functions are performed with more energy, and power is gained in every way.

This form of massage is especially beneficial in insomnia, general neuralgia, spinal pain, paralysis, muscular rheumatism, lumbago and sciatica, and when applied to the lower half of the body it diminishes over-excitability of the spinal ceuters, and is, therefore, especially useful in spasmodic states of the lower limbs, exaggerated reflexes, seminal emissions, etc. It is also especially useful in rheumatoid arthritis. It

alleviates the pain, relieves the stiffness, and frequently reduces the swelling of that affection. Electric massage excites the functions of organs and special senses, stimulates the skin, strengthens muscles and improves the nutrition of all parts to which it is applied.

THE STATIC INDUCED OR OSCILLATORY CURRENT.

This method of applying the static current was first brought out by Professor J. W. Morton, of New York, in 1881. The static "induced" current is a current of great power and peculiar properties. Professor Morton says of it as follows: "It is, in reality, a current differing from any other current in use in medicine, owing to the continuation of the high frequency of its alternations or oscillations (millions per second) and its high electro-motive force (several hundred thousand volts). It is essentially a high frequency, high potential current. No chemical decomposition attends its flow, but, in lieu of this, great muscular disturbance takes place. The resistance of the human body may be said to be almost nil, and all parts are easily and equally penetrated by it."

In this application it is not necessary to insulate the patient, the patient being seated upon an ordinary chair. To each pole of the battery is hung a small Leyden jar, and to the outer coating of the jar an insulated cord is attached by means of a brass hook. The poles are brought closely together, but not directly in contact, and when the battery is put in motion they are gradually separated by a screw-like motion, care being taken not to separate them too abruptly or a sudden shock may be the result, which, to a nervous, sensitive patient, may be very painful. The strength of the current is regulated by the amount of separation of the poles; also by the size of the Leyden jars used.

If, however, a device, as represented in Fig. 14, is employed, the strength of the current is regulated, not by separating

the poles as above given, for in this case the poles are separated widely before the battery is put in motion, but by working a screw in the device. Remember that the jar from

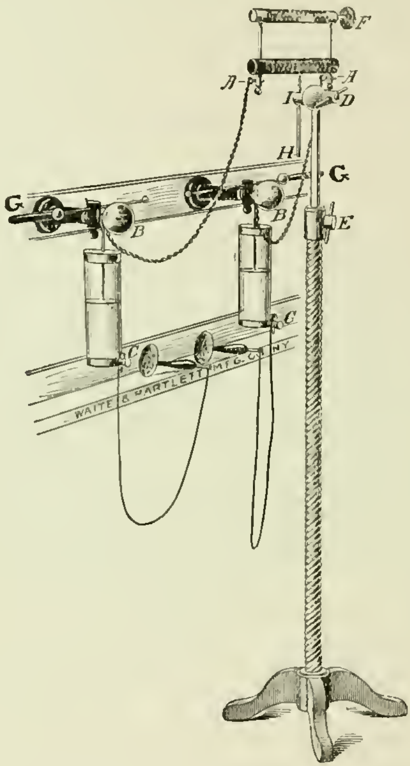


FIG. 14.—A STATIC INDUCED ELECTRODE. A device for converting static into dynamic or current electricity, thereby making a static machine perform the work of a faradic battery. By its employment this current can be applied painlessly to any portion of the body. To connect this instrument with the static machine, place it in the slot *I* and fasten with screw *D*. The conducting chains connect from *AA* to the pole rods *BB*, just back of the pole end balls. To use, connect the sponge-covered electrodes to the binding posts *CC*, on the brackets holding the Leyden jars, and govern the strength by the screw *F*. The pole-pieces *GG*, on static machine, should be pulled from four to eight inches apart.

the positive prime conductor is negative, and the one attached to the negative prime conductor is positive. Hence, if the

active pole is to be positive, it must be attached to the jar connected with the negative prime conductor.

The great objection to the use of this valuable therapeutic agent, hitherto, has been from the imperfect contrivances used, which gave sudden and painful shocks—the transition from mild to strong currents being abrupt and unavoidable; but this objection has been overcome by the improvement in electrodes, so that now the increase of current can be regulated as evenly as can the galvanic or faradic current.

The static induced current resembles in many respects the secondary faradic current, but differs from it, in that it has a fixed polarity and direction; also, it is more powerful and penetrating.

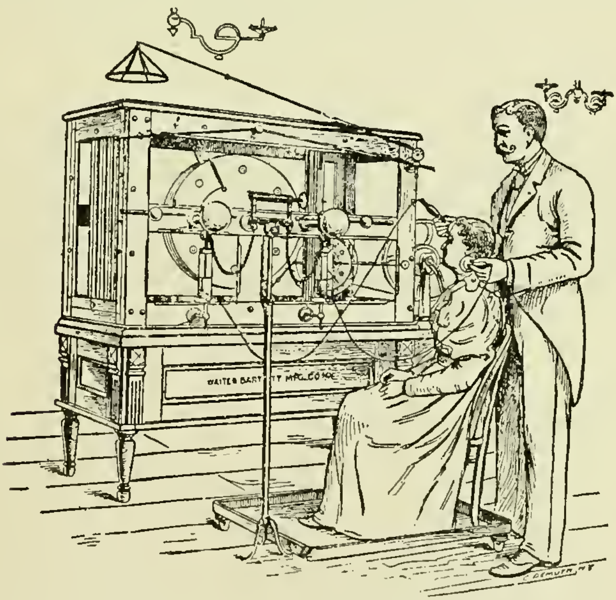


Fig. 15.—Showing Method of Using the Static Induced Current.

This current acts both as a revulsive, and by a kind of profound interstitial massage—and action resembling that of the faradic current. It has, besides, the polar and inter-polar properties of the galvanic. These two associated actions pro-

duce a more or less durable analgesic effect, which rarely fails.

The beneficial effect of the static induced current is marked in the relief of lumbago, muscular rheumatism, sub-acute and chronic affections of the joints, ovarian or pelvic pain, sciatica and pleuritic stitches.

In the treatment of paralysis it will often prove of more benefit than either the faradic or galvanic current. It excites muscular contractions more readily than the faradic current, and with little or no pain; muscles will react when not the slightest reaction can be obtained from the strongest bearable application of the faradic.

It is a most powerful tonic to weakened muscles, and is especially useful in the treatment of paralysis in children, as it does not hurt or frighten them, which cannot be said of any faradic current, however skillfully applied.

Facial paralysis is a difficulty frequently occurring, and yields quickly to the static induced current when there is no organic change in the nerve.

The static induced current is especially applicable to diseases of the cord, on account of its great penetrating power.

In cases of general debility, neurasthenia in all its various forms, and convalescence from various diseases, it has proved a most valuable adjunct to medical care.

SINUSOIDAL OR RAPIDLY ALTERNATING ELECTRIC CURRENT.

Within a few years much interest has been developed in a newly described form of an electric current, termed "sinusoidal" by D'Arsonval, by reason of the regularly sinusoidal form of the curve produced by the current when graphically represented.

By the sinusoidal current is meant an alternating induced current, in which not only the rise and fall of potential or electro-motive force of positive direction is immediately suc-

ceeded, without break, by an exactly corresponding rise and fall of potential of negative direction, but this rise and fall in both directions would, if shown with accuracy in diagram, describe a sine curve. The apparatus consists of a permanent magnet, between the poles of which an armature revolves, while a coil with a soft iron core is connected with each pole upon the outside.

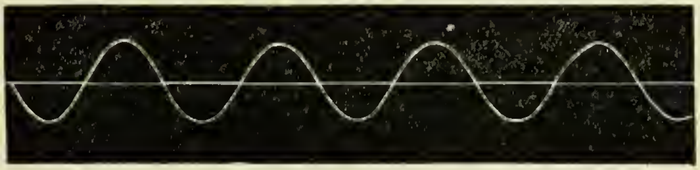


FIG. 16.—REPRESENTS TRACING MADE BY CURRENT FROM A SINUSOIDAL APPARATUS.

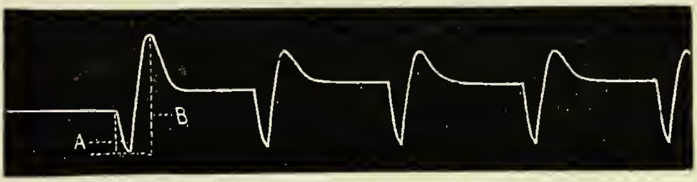


FIG. 17.—REPRESENTS TRACING MADE BY CURRENT FROM A FARADIC BATTERY. *A*, make; *B*, break. By comparing the above tracings, the great difference between the smooth and wave-like motion of the sinusoidal, as compared with the irregular marking of the faradic current, is readily seen.

The sinusoidal is a rapidly alternating current in which the increase of potential is gradual and uniform, the electromotive force is high, and the alternations of great frequency—14,000 to 16,000 per minute.

With oscillations sufficiently rapid (five hundred thousand to one million per second) currents of sufficient strength to light an incandescent lamp may be passed through the body without being felt, with the exception of a little heat being experienced at the points of entrance and exit of the currents from the body. Such currents would produce most terrific

effects if the frequency of oscillations was lessened. The increase and decrease of potential in this form of current is gradual and uniform, and never abrupt nor sudden in its change. The effect of this special feature of uniformity of the sinusoidal current is to lessen the disagreeable effects of electric excitation both on the sensory and motor mechanism.

This current possesses properties belonging to both the galvanic and faradic currents. It resembles the faradic, in that it is a good excitant of muscular contraction and is capable of producing a profound interstitial massage; the galvanic, in that it possesses polar and inter-polar actions.

The current derived from the secondary circuit on an induced coil has been shown to be alternating, but the positive and negative alternations differ considerably in electro-motive force and the gradations from zero to the greatest difference of potential in either direction are not regular and uniform, but quite the contrary. Moreover, the secondary current of the induction coil is interrupted, the time interval occupied by the interruptions exceeding considerably that consumed by the passage of the current. In these respects the secondary current of the induction coil differs from the sinusoidal alternating current in its physical properties, and these physical differences have of necessity a corresponding difference in physiological and therapeutical effects.

The alternating current dynamos, now used so extensively for lighting incandescent lamps, furnish a current which is roughly sinusoidal, and can be utilized by physicians who have access to it and have some form of apparatus, like the Waite and Bartlett Current Controller, suitable for modifying its strength and voltage. As the speed of the dynamos, while in action, is quite uniform, the number of alternations do not vary much, and the frequency is often much less than is wanted in therapeutic work, being about 124 alternations per second. It is convenient and oftentimes quite desirable to have an apparatus for the generation of the sinusoidal cur-

rent so arranged that the operator can vary the frequency of alternations, the electro-motive force and the current at will; and this is possible with some of the machines now manufactured.

The physiological effects produced by the sinusoidal current which are most characteristic of it are (1) its painlessness and (2) its great penetrating power. It possesses the remarkable property of producing painless muscular contraction; that is, the only sensation produced by an application sufficiently strong to induce tetanic contractions being a slight pricking of the skin. This is due to the great penetrability of the current. The applications are painless, and afford excellent exercise to muscles, producing marked contractions without any other sensation than that of motion. The effects can be limited to a single muscle or set of muscles.

For exciting to vigorous action muscular tissue, therefore, whether it be the voluntary or involuntary variety of muscles, the sinusoidal is the current par excellence. Such frequency of alternations can be used as will adapt the excitation of the requirements of the muscular structure. The comparative painlessness of the applications permits the use of greater electro-motive force and more current than can be used either from the induction coil or the primary battery, so that the physiological action of the muscles is more thoroughly aroused than by the use of either of these other forms.

When run at a high rate of speed, it is found to be remarkably smooth and pleasant in application, and is much less active in exciting cutaneous irritability than an ordinary faradic current. When the machine is run slowly it produces interrupted contractions and when run rapidly causes tetanic or continuous contractions.

The special therapeutic sphere of the sinusoidal current is in the cure or amelioration of chronic diseases. In acute diseases and nervous affections (excepting pain) it is not well indicated. All patients suffering from debility resulting from some defect in nutrition are, as a rule,

benefited by this current. This current exerts, in the majority of cases, a most powerful and generally beneficial action upon these diseases by accelerating organic exchanges and combustion. This is proved by analysis of the urine. The quantity becomes more normal, the products of organic waste are better eliminated, and the increased combustion is shown by the diminution of uric acid, while the percentage of urea is generally increased. The relative proportion of these two substances changes under treatment so as to reach in general the figure of 1 to 40. The elimination of the mineral products is also changed, but in a less marked manner.

It increases the respiratory circulation to the extent that the amount of oxygen consumed is increased by about 50 per cent., with a corresponding increase of urea, carbonic acid and other final products. By the effect of the increased organic combustion obesity is benefited. Asthma, anæmia, and chloro-anæmia are influenced favorably; also general muscular weakness, local paresis or paralysis, lack of intestinal peristalsis, vaginal and rectal prolapsus due in whole or in part to lack of muscular tone, and vaso-motor debility are some of the conditions in which this form of current has proved especially beneficial; it is particularly efficient in the treatment of infantile and pseudo-hypertrophic paralysis.

The diseases, however, which have derived most benefit belong to the arthritic class,—rheumatism and gout. In certain diabetic subjects the sugar disappears altogether from the urine, while in others there is no general change, notwithstanding the manifest and constant improvement in the general condition.

It is a rapid and efficacious analgesic. Pain is particularly amenable to this form of current. In the treatment of pain, whether muscular (due to rheumatic origin), or neuralgic (with or without neuritis), the benefit derived from this form of current is, as a rule, marked even from the first application; the patient feels better, suffers less, executes various

movements with greater or less ease which previous to the treatment were painful.

It is a good excitant of muscular contraction. When we consider how many normal processes of the body, such as assimilation, circulation, secretion, exertion, locomotion, etc., depend directly upon muscular tone and vigor, it will be seen at a glance what a wide range of therapeutic application is possessed by this form of current in the field of muscular excitation alone.

The sinusoidal current being both electrolytic and undulating, it causes simultaneously two sensations at the points of application, which are associated together. The first is that of the continuous current. The second is that of an interrupted current, but with infinitely more smoothness than that of the faradic current, on account of alternating electric wave and the sinusoidal curve which makes this undulating current.

This current may be applied in two ways: (*a*) The hydro-electric bath; (*b*) the local application with electrodes. In the first method the patient is placed in a tub, made of enameled iron and insulated, and filled with tepid water. The electrodes consist of two rectangular plates of carbon, covered by an insulated bed of hard rubber on one of their faces; they are movable, and can readily be placed so as to localize the active pole at the precise spot where the maximum effect is desired. With this mode of treatment intensities of from 50 to 120 ma. can be reached.

The bath appears to have marked advantages in many cases, as it permits the use, not only of the chief local polar action, but also of a supplementary and diffuse general action on the entire body, coming from many sources of current in the water of the bath. In the second method the applications are made similar as when the galvanic or faradic currents are employed; the same electrodes serve with this current as in those.

Generally a medium dose, which is well tolerated, is

enough, and the precaution should be taken to use an electrode large enough to cover all painful surfaces, on which it should be placed closely.

When treatments of fifteen minutes are given every other or third day we may generally observe in the patients (1) a return of sleep; (2) an increase of strength and vital energy; (3) an increase of gayety, of power for work and ability to walk; (4) an improvement in appetite, etc. In short, a general progressive improvement. This general improvement often manifests itself after the first *seances*, before any local influence is apparent and before any change has occurred in the urinary secretions. Local pain and trophic changes are often more slowly affected, and at times are entirely refractory for a longer or shorter period. In such cases the currents must be applied locally by contact with the electrodes.

The sinusoidal current takes precedence in many cases chiefly on account of the following properties: It is a rapid and efficacious analgesic; it is a powerful decongestant; it is a good excitant of muscular contractions; it possesses the qualities of galvanism and of faradism.

ELECTRIC LIGHT.

Both the arc-light and the incandescent lamp have been used therapeutically. Attention was first drawn to this form of current by the fact that since the introduction of the system of electric welding in the large iron works there has been a noticeable diminution in the number of cases of rheumatism, neuralgia, migrain and other nervous diseases among the workmen.

Its principal use has been in connection with constitutional diseases for its nutritional effect, and in painful affections on account of its analgesic properties. It is especially beneficial in sciatica, chronic rheumatism, lumbago, facial neuralgia, neuralgia of any form and neuritis.

The patient is placed at a distance of one and one-half meters from the light and protected by blue spectacles, and

also by a screen of card board in which an aperture is cut to allow the light to fall upon the affected region of the body for from three-quarters of a minute to two minutes. At the time the patient feels a slight sensation of heat, but nothing more until six or eight hours afterwards, when itching and tingling are felt and the skin becomes reddened. Some forty-eight hours later desquamation occurs, which lasts for two or three days. The treatments are given at intervals of three or four days, according to the amount of cutaneous irritation. As a rule, by the time three or four treatments have been given the pain will be relieved and the improvement in the general condition will be marked; rarely is it necessary to exceed a dozen sittings.

SPECIAL ELECTRO-THERAPEUTICS.

The Application of Electricity to Special Organs or Parts and to Special Diseases.

We now come to the consideration of the action of electricity in individual forms of disease, the indications for the use of this remedy, and the methods suitable in various diseases—that is, to *special electro-therapeutics.*

It is not the purpose of this work to go into detail as to causes, symptoms, pathology, etc., of the various diseases, but merely to bring forward quite briefly an account of the facts which have been established, and of the methods which are to be employed in the electrical treatment of these conditions.

ELECTRIZATION OF THE BRAIN.

Formerly it was supposed that an electric current would not penetrate the brain-substance, but it has been demonstrated conclusively that the current, when applied to the head, traverses all portions of the brain equally.

The brain may be affected directly by galvanizing the head and neck, or indirectly (reflexly) by stimulating the integument and the peripheral nerves. To galvanize the brain,

one of three methods may be employed: (1) Place one electrode on the forehead, and the other to the occiput. (2) Place one electrode to the left and the other to the right temple. (3) Place one electrode to the right and one to the left mastoid process. If, however, one hemisphere is to be galvanized, as in certain cases of hemiplegia, place one electrode over the eyebrow and the other in the hand of the same side. In case the patient is very sensitive to the use of electricity, Althaus advises that one electrode be placed at some distant part of the body, as the palm of the hand, the sternum, etc.; then use the indicated pole to the forehead, temples, or nape of the neck.

According to Lowenfeld, when the positive pole is placed on the forehead and the negative on the back of the neck (descending current), a contraction of the blood-vessels of the brain and its membranes occurs; by this arrangement of the poles the flow of the blood to the brain can be diminished. When the negative is placed on the forehead and the positive to the nape of the neck (ascending current), a dilatation of the vessels results; this method of applying the poles increases the flow of blood to the brain and accelerates the circulation. When the electrodes are placed on opposite sides of the head, a dilatation of the blood-vessels lying beneath the positive pole is produced, and a contraction of the vessels in the side on which the negative pole is placed; therefore, the positive pole is to be applied to the diseased side if the circulation of the brain is to be increased, and if it is to be diminished, the negative.

Less dizziness is caused if the current passes through one side of the head only, or from forehead to occiput, than when sent from one side to the other through the temples or mastoid processes. When applying electricity about the head, and the patient complains of dizziness, it is an indication that the current is too strong or that the sitting has been prolonged too long. Galvanization of the brain must be prac-

ticed with caution, especially in patients threatened with, or who have had a previous attack of, apoplexy.

All applications of electricity to the head should be brief and made with a current of moderate strength. The sitting, when the stabile method is used, should not last over two or three minutes; when the labile method, the sitting may last four or five minutes. The strength of the current should be made to depend absolutely upon the sensitiveness of the individual to the current, always keeping in mind that some individuals are more easily affected than others. Great care should be exercised in turning the current on and off gradually, so as to avoid a shock.

Galvanization of the brain is indicated in various functional nervous diseases, such as insomnia, headache, nervous exhaustion and insanity.

All organic affections of the brain in the absence of acute symptoms are amenable to galvanization. Cerebral hæmorrhage, softening, sclerosis, meningitis subacute and chronic, are among the organic diseases treated by the galvanic current.

In galvanization we have a valuable adjunct in the treatment of congestion of the brain. Various congestive states of the brain, which, if unchecked, would undoubtedly result in organic disease, may, by the use of this agent, be averted. In the application of the galvanic current to the brain to antagonize various congestive states, Dr. Mann advises placing the positive pole at the level of the superior ganglia of one of the cervical sympathetic nerves. The current should be interrupted, since vascular contractions occur most markedly at the opening and closing of the circuit.

When cerebral anæmia of a general character exists, general faradization, central galvanization, and static electricity by insulation are often of material benefit. Franklinic electricity, in the form of the static breeze applied to the head, is a powerful modifier of the intracranial circulation. In addition to the direct application of the galvanic current to the

brain, much benefit can be obtained from general faradization and from the use of static electricity to the extremities. That the application of electricity to the peripheral nerves acts as a powerful reflex stimulant to the brain cannot be doubted. Nothnagel observed contraction of the cerebral blood-vessels following electrization of the skin and sensory nerves. Rumpf found that faradization of the skin of a limb caused transient anæmia, followed by congestion of the opposite hemisphere.

The faradic current passed in any direction through the brain produces at first anæmia, caused by contraction of the blood-vessels of the brain, which is quickly followed by hyperæmia, due to paralysis of the blood-vessels.

ELECTRIZATION OF THE SPINAL CORD.

When the galvanic current is used, the spine should be thoroughly galvanized. To accomplish this the following method may be employed, according as to whether we want stimulating or sedative effects: The spinal cord is stimulated or excited by passing the negative pole up and down the spine, the positive pole being placed at some indifferent part of the body, as the sternum or the abdomen; the reverse of the poles produces sedation. The negative pole at the upper end of the cord and the positive at the lower end produces anæmia; while the reverse of the arrangement produces hyperæmia. The negative pole above and the positive pole below excites and increases the reflex excitability of the cord and the excitability of the reflexes.

The galvanic current is of greater service in the treatment of spinal diseases than the faradic current, or perhaps the static—chiefly on account of the depth of the tissues affected and the chemical and molecular changes which the galvanic current tends to induce.

The cord may be affected reflexly by stimulation of the peripheral nerves by means of the faradic or static current. In some unexplained way the excitation of muscular action

and stimulation of the cutaneous nerves exerts in many instances a remedial effect upon lesions of the spinal cord.

PARALYSIS.

By the term *paralysis* we mean a loss of the power of motion. However the term of paralysis is sometimes used to indicate a loss of any kind of function, as paralysis of sensation or secretion. A slight, incomplete or partial paralysis is termed *paresis*.

When a paralysis is confined to one limb or a group of muscles it is known as a monoplegia. When it affects one lateral part of the body it is termed a hemiplegia. When the upper or the lower half of the body is paralyzed it is called a paraplegia, although when the term paraplegia is used it generally signifies a paralysis of the lower half of the body. When both the upper and the lower extremities are paralyzed it is termed a double hemiplegia or diplegia. Paralysis may be of cerebral origin, spinal origin, or due to lesions of the peripheral nerves.

In every case of paralysis that comes to us there will arise the questions, "Will electricity do any good in this case, and if so, what form is to be used?"

The amount of benefit to be expected from the use of electricity and the form of electricity (faradic, galvanic or static) to be used depends entirely upon the pathology of the different cases. Every case of paralysis will not be benefited by the use of electricity.

In cases of paralysis of long standing, due to destruction of a large area of the nerve center (brain or spinal cord), electricity will do little if any good, and may cause aggravation by its use. When cerebral paralysis is advanced to the stage where "spastic paraplegia" is developed, treatment rarely does any good. When contractures take place, the prognosis as regards a recovery of the deformity is bad, for contractures seldom ever recover.

In paralysis of an arm or leg with atrophy and tonic con-

traction of the hand and wrist, or foot and ankle muscles, the prognosis from electrical treatment can only refer to improving the general health and local nutrition and strength. The chief symptoms will remain about the same except so far as they are ameliorated by the process of nature.

If the muscles are much wasted and refuse to respond to the application of either the faradic or galvanic current, the prognosis is unfavorable, yet by persistent treatment some benefit may finally be obtained.

In those cases, however, where it is indicated, it will give brilliant results, for it is in the treatment of the various forms of paralysis that electricity has won its greatest laurels. If the central lesion is an effusion, which will absorb, or an injury, which time will make better, the prognosis will be an improvement in proportion as the central impediment disperses. These cases of hemiplegia and paraplegia can be improved with great satisfaction by electrical exercise of the muscles, while, if left to time alone, the paralysis would long linger after the effusion was absorbed.

In cases of paralysis due to acute congestion and its consequent effusion, it is often the case that the function of the nerves leading out from the affected area remain dormant long after the effusion has become re-absorbed. Cases of this kind can be quickly benefited by the application of electricity. It arouses, as it were, the dormant functions of the nerves and often will at once restore as complete power over the affected limb as the state of the muscles, weakened by previous disorders, will admit of.

In all cases of mechanical injury to the nerve trunk the prognosis will be good if the anatomical integrity of the nerve is either maintained or can be restored. Any injury which destroys the path of conduction renders a cure impossible.

In the majority of cases a careful investigation into the history of the ailment will enable the practitioner to determine whether electricity will be of service in any particular case or not.

So often, in the treatment of paralysis, electricity is looked upon as a remedy to be brought in use after all else has failed. This is a serious mistake, for electricity is one of our best curative agents in the earlier stages of paralysis on account of its power of causing re-absorption of the inflammatory and hæmorrhagic products of the lesions.

A question of great importance is, how soon after the attack should the electrical treatment commence? This will depend upon the nature and severity of the case. In a mild case treatment can be begun sooner than in a severe one. In a case due to cerebral hæmorrhage, if there are symptoms of a secondary stroke, treatment should be delayed until that danger has passed; also treatment should not be begun until the danger of cerebral fever, which so often follows an attack of hæmorrhage, should have passed off, and this, if it occurs, comes on from the fourteenth to twentieth day according to the severity of the paralytic stroke. The treatment should not be delayed beyond this period, for it lessens the prospects of ultimate recovery. In paralysis of spinal origin the same rule is to be followed; while in paralysis of peripheral origin the treatment can be commenced much sooner.

In the treatment of paralysis, certain fundamental principles apply to nearly all cases. There must be: (1) Treatment of the seat of the disease, brain, spinal cord or nerves as the case may be, to endeavor to cause absorption of the inflammatory or hæmorrhagic products in order to remove the cause of the paralysis; (2) treatment of the paralyzed muscles, in order to maintain their nutrition and their activity, thus preventing them from atrophying. However, stimulation of the peripheral parts may also act usefully by influencing the central organs through the medium of the sensory nerves, and in a reflex manner may set up motor impulses along the nerves to the paralyzed parts; this tends to restore the conductivity of the nerve if that be at fault; in other words, such peripheral treatment has as its object the restoration of the normal influence of the will on the muscles; also

it is certain that changes are set up in the centers when their peripheral areas are stimulated, and in this way cures have been effected, even when the treatment has been applied only to the peripheral parts.

In paralysis of cerebral origin the treatment should be directed to the seat of the lesion, so as to promote the process of absorption of the clot. The process of absorption is generally finished thirty or forty days after the attack. *Only* the *galvanic* current should ever be applied to the cerebral hemisphere; the negative pole to be applied over the seat of the lesion, and the positive over the nape of the neck. Begin with a mild current, 3 to 5 ma. Shocks must be carefully avoided. The sitting should be continued from five to eight minutes, and repeated twice or three times a week.

The *faradic* current should *never* be applied to the brain during the acute stage. A mild faradic current has no therapeutical effect on the nerve-centers, while an injudicious application of the faradic current of a high degree of power to patients who have suffered from cerebral hæmorrhage is liable to bring on another attack.

In paralysis of spinal or of peripheral origin the same rules are to be followed as are applicable to paralysis of cerebral origin, namely, electricity in the acute stage must be avoided; the galvanic current to be employed, placing the negative pole directly over the seat of the lesion, and the positive at some indifferent point; begin with a mild current (5 to 10 ma.) and increase the strength of the current as the patient becomes used to it; but the strength of the current should never be pressed to such a point as to produce pain or any unpleasant symptoms during or after the sitting; treatments every day, or every other day, or every third day, according to the severity of the case. In those cases of spinal paralysis (chronic dorsal myelitis) where the limbs are well nourished and the reflex action excessive, as indicated by spasmodic jerks of the limbs, fingers, and toes, electricity in

any form should not be used, as it over-stimulates the sensory nerves and increases reflex action.

In cases of paralysis, whether of cerebral, spinal, or peripheral origin, after the acute inflammatory process has subsided, the treatment of the muscles should be begun with the faradic current, providing that this current will produce contraction of the paralyzed muscles; but in a case where the faradic current fails to produce any muscular contraction it is useless to apply it. The galvanic current should be used until the muscles again respond to faradism. The paralyzed muscles are to be treated by applications of the negative electrode, which must be well moistened and move firmly and slowly over the affected muscles; the indifferent electrode is to be placed over the cervical or lumbar region of the spine. Each time, after applying the galvanic current, the faradic current should be tried, and just as soon as it will produce contraction of the muscles it should be used in preference to the galvanic current. The paralyzed muscles can be faradized directly by the application of the active electrode over their surfaces, or indirectly by its application to their motor nerves, that is, to the motor points; in either way similar results are obtained. When the paralyzed muscles do not react to faradism, and nerve-degeneration is present, its persistent use is liable to aggravate the case by strengthening the opposing or non-paralyzed muscles, and thus hastening deformity by undue action of those muscles; for it must be remembered that healthy muscles, as a rule, increase in strength faster than the diseased ones by the same treatment. In such a case the galvanic current should be used. The galvanic current has power to improve nutrition and strengthen, even though it does not produce contraction, and should be given by labile application until reaction returns or the case is found to be incurable.

When the muscles fail to respond to either faradism or galvanism, the galvanic irritability, in some instances, may be

restored after a few applications of the sparks from the static machine.

The interrupted galvanic current in some cases serves as an adjunct to other treatment in restoring the power to paralyzed muscles. It is possible, by means of the interrupted galvanic applications, to preserve the nutrition of the muscles even though the paralysis remains unimproved.

When there is very much contracture of the muscles, the application of *static sparks* will often prove of valuable service; also where there is much atrophy of the muscles, the fine sparks, applied by means of the roller, will in many cases start up nutrition in the paralyzed muscles more frequently than any other form of treatment.

When using the faradic current place a long, flat electrode on the back over the lumbar plexus, if the lower limbs are paralyzed; or the cervical plexus, if the upper limbs are paralyzed, and then apply the other pole to each muscle successively. The active electrode must be well moistened and passed slowly and firmly over the affected muscles. The current should be just strong enough to produce a moderate contraction of the muscles. Each sitting should last about ten minutes, and be repeated twice or three times a week, according to the nature of the case.

In the "static-induced" current we also have a most powerful agent in the treatment of paralysis. The advantage of this form of current over general faradization, or the interrupted galvanic current is that it produces more readily muscular contraction even to a great degree, and without causing the slightest pain or disagreeable sensation to the patient; also in its reflex action it has proven to be strongly tonic, not only to the nerve itself, but the whole system as well. Its method of application is as follows: If it is the arm that is paralyzed, have the negative electrode held to the palm of the hand, and, with the positive pole, go over thoroughly the motor-points of the muscles of the arm and shoulder. If it is the leg that is paralyzed, place the negative electrode at the

sole of the foot, and apply the positive to the motor-points of the muscles of the leg, thigh, and hip. In this way contractions of each muscle, or group of muscles, can be readily produced.

For the anæsthesia which is associated with the various forms of paralysis the faradic wire brush will prove invaluable. The current should be as strong as can be tolerated, and continued from three to five minutes. The other electrode can be placed at any indifferent point. In some instances the sensibility is permanently restored after two or three applications.

Caution is always advisable at the commencement of each case to avoid overtaxing weakened muscles by too vigorous stimulation. Short sittings, with slow and mild contractions at first, can be gradually increased in amount of exercise until the muscles endure very thorough treatment without fatigue.

The "combined current" (galvano-faradic) is chiefly of service in overcoming trophic disturbances, which often manifest themselves in connection with motor paralysis.

Besides the paralysis in these cases, the general health always improves. The whole nervous system seems to be reorganized.

One great difficulty in the treatment of any form of paralysis is to keep hold of the patients a sufficient length of time. At first they are faithful to their treatment, but as time goes on and, as is the case with most chronic cases, they will grow weary of the trouble and expense, and because the cure is not speedy, they will stop.

INFANTILE SPINAL PARALYSIS.

(*Acute Anterior Polio-myelitis.*)

This affection consists of an inflammation and destruction of the gray matter (motor and trophic cells) of the anterior horns of the spinal cord; and, as a consequence of the destruction of the cells (motor and trophic), there is developed

an acute form of paralysis followed by rapid atrophy of the paralyzed muscles, without sensory, vesical or rectal disturbance.

There can be no doubt as to the beneficial effects of electricity in this affection, for it is an exception for a muscle to be so completely destroyed by polio-myelitis as to have no functional fibers left; so that by persistent stimulation great development of the remaining fibers may be produced. Even a long time after the disease has occurred and left some paralyzed muscles, if these muscles have retained their electro-excitability they can be very much benefited by electricity.

If the farado-muscular contractility is entirely abolished, while yet there remains distinct galvano-muscular contraction, we have good grounds for believing that much may be accomplished by persistent treatment. If the galvano-muscular contractility is also lost, the case is generally hopeless; for, with the absence of this reaction, we expect to find muscular atrophy and degeneration. In other words, if the muscular fibers preserve their transverse striation, as indicated by their reaction to galvanic stimulation, there is hope of ultimate recovery, or at least of improvement; but when this reaction progressively grows less and is finally lost, the transverse striations have been replaced by glandular and fatty degeneration, and no treatment can hope to be of service.

The electrical treatment may be begun as soon as the inflammatory process begins to subside—fourteen to sixteen days. As a rule, the treatment should be begun with the limbs, using a mild faradic current. The negative pole (labile) should be applied to the affected limb; the positive, applied to some indifferent part of the body—for instance, the sternum. Within a few days the central lesion (spinal lesion) should be treated; the negative pole (galvanic current) being placed over the seat of the lesion, the positive over some indifferent part of the body. The treatment should be given two or three times a week. By this means we may hope to aid the regeneration of the atrophied neuro-muscular elements,

and to avert the degeneration of others which may have been less severely injured.

During the second and third stages the interrupted galvanic current (negative to the extremities) is of great service and will usually prove of more benefit than any other form of electricity. The application of a slowly interrupted galvanic current to the nerve trunks supplied from the diseased area appears to awaken a reparative effort on the part of the ganglion cells. We may not for a long time find any visible response in muscular contraction, but if this treatment is persisted in the result will prove much more satisfactory than would seem possible at first. Also the faradic and the static induced currents are to be employed during these stages. The same rules governing their application are to be employed as were given for "Paralysis," which compare.

The treatment must be continued for a very long time; from six months to a year, and in some instances a short course of treatment once or twice a year. Rubbing or massage may be advantageously combined with the electrical treatment.

FACIAL PARALYSIS.

There are two types of facial paralysis, *cerebral* and *peripheral.* In the cerebral type the lesion affects the brain or the nerve-path from the cortex to the nucleus in the floor of the fourth ventrical, and the face is paralyzed chiefly in the lower part, the muscles of the upper part of the face, especially the orbicularis palpebrarum, rarely being implicated (the patient can close the affected eye as well as the normal one), and associated with this there is usually monoplegia or hemiplegia; there is no loss of faradic irritability.

In the peripheral type the lesion may affect the nucleus or the nerve at any point between the nucleus and its peripheral distribution. The part of the nerve which is most frequently affected is that which passes along the Fallopian aqueduct. In this part a very little swelling of the nerve or of the walls

of the aqueduct is sufficient to cause compression of the nerve-fibers.

When the lesion affects the nucleus or the nerve proper, all branches of the nerve are affected, and consequently the muscles both of the upper and lower part of the face are completely paralyzed. This form of paralysis is termed *peripheral paralysis* of the seventh nerve, or, more commonly, "Bell's palsy," after Sir Charles Bell, who divided this nerve, with the erroneous idea of curing facial neuralgia, and afterward gave a full description of its nature.

The prognosis is usually favorable. It depends upon the character and seat of the lesion. If due to neuritis caused by cold, or if due to syphilis, it is usually favorable. The prognosis is mainly founded on the electrical reaction. According to Gowers, if at the end of ten days the irritability of the nerve is not below the normal the face will probably be well in a few weeks. If, on the other hand, at the end of two weeks the irritability of the nerve is absolutely lost, the paralysis will certainly last for several months. If at the end of two weeks the nerve-irritability, although lowered, is not lost, recovery will probably occur in about two months. When the faradic irritability has been absent for some weeks, any return of excitability in the nerve-fibers indicates à speedy return of some power of them. In the great majority of cases faradic irritability begins to return at the end of five or six weeks.

Of all forms of paralysis, especially should facial paralysis receive early and systematic electrical treatment; for only a very slight loss of power of a muscle, or a group of muscles, interferes with the harmonious actions of the facial muscles as a whole, and thereby causes an unsightly deformity.

The form of current to employ will depend upon the state of electrical irritability of the muscles supplied by the facial nerve. If the muscles respond to the faradic current, this is the form to employ; but if the faradic current induces but very slight contractility, it is better to alternate its use with mild

galvanic currents. If, however, there is no response to faradism, the galvanic current is called for, and should be used until there is some indication of farado-muscular contractility, when the faradic current should be substituted.

The faradic current should not, however, be used when the muscles on the affected side contract more readily than on the healthy side; also when this contractility is diminished so far that a painfully strong current is necessary to produce contraction.

When employing the faradic current place one electrode on the back of the neck, and with the other touch the paralyzed muscles. Go carefully over these muscles, making each one act.

In using the galvanic current, place the positive electrode on the nape of the neck (sometimes it is better to place it either over the stylo-mastoid foramen or in the fossa below the ear), and move the negative over the trunk and branches of the facial nerve—the electrode being pressed firmly to the parts. At times the negative electrode should be held in position over the various branches of the nerve in turn (stabile method), and the current allowed to pass for one minute at each point. Each group of muscles is then made to contract by the interrupted galvanic current, by the opening and closure of the circuit, without its removal from the surface of the skin. The strength of the current (4 to 8 ma.) must be graduated according to the sensations of the patient. In the neighborhood of the eyes this may be diminished to avoid annoying flashes and vertigo; the treatment should last from eight to ten minutes, repeated every other or every third day until decided improvement and then the interval lengthened.

When a muscle fails to respond to either the galvanic or faradic currents, the static should be resorted to—the spray or mild sparks being applied to the affected muscle.

Massage will prove beneficial, and the patient should prac-

tice facial gymnastics daily. In those cases where the eye cannot be closed it should be protected by a shade.

LEAD PARALYSIS.

Lead palsy attacks with preference the upper extremities. Generally both arms are affected, and it is almost exclusively the extensor muscles of the hand and forearm which suffer, while the flexors either escape completely or only become weakened to a moderate degree. The muscles attacked waste away, and as a consequence of the atrophy of the extensor muscles of the forearm there is developed a condition known as "wrist-drop"—that is, the hand drops down and there is an inability to raise it again.

In cases of lead palsy the excitability of the muscles to the faradic current is always diminished and often entirely lost; and reaction of degeneration soon develops; sensibility is generally preserved.

The method of treatment is to place the positive pole over the cervical region and apply the negative to all the motor points of the affected muscles and nerves. The current should be interrupted, thereby producing a vigorous contraction of the muscles. In some instances beneficial results will be obtained by placing one large electrode over the cervical region and another over the sternum, and then passing a strong current for three or four minutes, and the current to be reversed; but the current should be reduced to zero before the polarity is changed, so as to avoid a shock to the patient.

ERB'S PARALYSIS.

Erb's paralysis is a form of paralysis in which one arm is affected, the consequence of injury to the fifth or sixth cervical nerves. The muscles paralyzed are the deltoid, biceps, brachialis anticus, infra-spinatus, and supinator longus; and occasionally the extensors of the hand.

This type of paralysis is met with more frequently in in-

fants, the result of forcible traction on the head and neck during delivery. Exposure to cold and dampness may also cause it.

Especially is electricity called for in this form of paralysis. In paralysis electricity acts by stimulating the functions of the nerves and muscles, and as nutrition bears a direct relation to activity of function we are thus enabled to prevent the wasting which so rapidly follows when a part is quiescent. If this is necessary in the various forms of paralysis in adults, it is more so in children, whose active, yet delicate, nutrition so rapidly suffers under depression. In young infants the tissues are not only active but growing, and in such cases any arrest of function is doubly injurious, and the general opinion in these cases is that if left to themselves they become incurable and end in atrophy of the limb.

Treatment should be begun a few weeks after the birth not later than one month. The treatment should conform to the indications furnished by the electrical examination. If no reaction is obtained to the faradic current, it is useless, even harmful, to apply it. The galvanic current should be used, the positive pole at the nape of the neck, the negative stabile upon the anterior of the arm, for a period of ten minutes, with a current of 4 or 5 ma. The seance is terminated by making closure contractions, with the negative pole placed upon the motor-points of the nerves and muscles. Treatment should be given at least twice a week. It is very important for treatment to be kept up for a long time, even if no results are apparent, for often improvement is very slow and by perseverance the child may be saved from a life of deformity.

NEURALGIA IN GENERAL.

Neuralgia (pain in a nerve) is a functional disease characterized by pain in the course of a nerve or nerves, which usually develops in paroxysms, either spontaneously or after pressure upon certain points. When there is organic disease of the nerve itself, such as neuritis, the disease cannot be, in

the strict sense of the term, called neuralgia. Many times such conditions are wrongly diagnosed as "neuralgia." It is often difficult, and sometimes impossible, however, to draw the lines absolutely and say that all on this side are neuralgia and all on the other side are neuritis.

A peculiarity of a neuralgic pain is that it may shift from one nerve or set of nerves to another. Every nerve of the body may be the seat of a neuralgia at one time or another. It is essentially a disease of adult life, and occurs more frequently in women than in men.

In electricity we have a valuable agent for giving not only temporary, but also permanent, relief in many of the most obstinate forms of neuralgia. By the judicious use of the static, galvanic, and faradic current the great majority of neuralgic pains can be satisfactorily relieved regardless of a differential diagnosis as to cause, and with permanent results if the cause be also one which is amenable to their action.

True neuralgia is most successfully treated by galvanism; while hysterical neuralgia and the so-called pseudo-neuralgias, which are simply forms of pain occupying certain areas running, seemingly, in the direction of certain nerves, yield most readily to faradism, or to static electricity.

As a general rule, general faradization is indicated in cases of neuralgia with impairment of nutrition and general muscular weakness; while exhaustion of the nerve centers, general nutrition and muscular power, being relatively intact, call for the galvanic current.

If the neuralgia is rheumatic in character, the static will prove of especial value, on account of its power of increasing oxidation and promoting metabolism; also patients of either class who are timid, nervous and very susceptible to electricity will receive more benefit from static insulation.

In neuralgia, when pressure over the affected nerve aggravates the pain, the galvanic current will be the one to choose; but if firm pressure gives relief and does not increase the pain, the faradic current will be the one to employ.

When using the galvanic current, place the positive electrode over the painful spot, or, if the painful area is quite extensive, move the electrode gently over the entire region affected; the negative pole is placed at some indifferent part of the body but as far distant as possible from the positive pole so that the positive possesses the most intense effect possible. Begin with a very mild current and increase the strength gradually. Often the pain will be aggravated at first, but will gradually subside as the treatment continues.

Often, when the neuralgia is superficial, temporary relief (lasting from three or four to twelve hours) can be quickly obtained by saturating the sponge of the positive electrode with a solution of cocaine (ten per cent.), aconite tincture or helleborine. Aconite produces a deeper analgesia than cocaine, but the objection to its use is that it causes severe smarting around the edges of the anæsthetized area. This, however, can be prevented by the employment of equal parts of cocaine (ten per cent. solution) and aconite. Helleborine (four or five drops of a one per cent. solution on the sponge of the positive pole) produces a deeper and more lasting anæsthesia than cocaine, and is never followed by any constitutional effects, as occasionally follow the employment of cocaine. In some cases of intense and obstinate forms of neuralgia, where the pain is almost unbearable, prompt temporary relief may usually be obtained by saturating the positive sponge with a preparation of one part aconite, two parts of laudanum, two parts of chloroform, and four parts of alcohol, and holding the positive sponge over the seat of the lesion; this will usually control the most severe cases. Mild currents should be used, as the burning beneath the positive electrode is much more severe when using this liniment. Care should be taken to gradually increase and decrease the current, avoiding any interruptions or reversals of the current. A three to five minutes' treatment will be sufficient.

If the faradic current is indicated, it will almost always cause an aggravation of the pain at the beginning of the

treatment, but after a few minutes this temporary irritation gradually subsides and soon all pains cease or are greatly ameliorated.

In some forms of neuralgia counter-irritation seems to give better results; and in such cases the faradic current applied either by the passage of a very strong current through the trunk of the nerve and its branches or by the application of the faradic brush to the integument supplied by the affected nerve meets with success.

The application of the static sparks will in many cases not only give temporary relief, but also cure the neuralgia. If the neuralgia is located about the head, face, or any sensitive region, it is better to employ the wooden or carbon electrode, as they produce a milder spark and are less painful than the brass ball electrode; in many instances the spray will prove of more benefit.

In treating neuralgia, benefit is obtained in almost all cases; the pain easing down during the treatment and relief following for a certain length of time after the first application; then the pain will return, perhaps with diminished severity, at which time another application should be given. Each sitting thereafter produces renewed relief, until eventually the pain ceases to return and the case goes on to complete recovery. In other cases this improvement may continue from the first and require no more treatment, or at most only one or two.

The electrical treatment of *cervico-occipital* neuralgia does not present the slightest difficulty, since we have to deal with superficial and quite long nerve-trunks, which can be readily influenced, as far as their entrance into the central organs, and whose most frequent sites of disease are usually reached with facility. Place the positive pole over the exit of the nerves (the upper cervical vertebræ), the negative upon the sternum. The results are usually admirable, but some cases occur which resist treatment.

Intercostal neuralgia is often very obstinate. The rheu-

matic, neuritic and traumatic forms are relatively favorable; but those forms which are due to vertebral disease, tabes, pulmonary phthisis, and the like are very obstinate and often incurable; while those varieties which are associated with herpes zoster in old people often present a surprising persistence.

The ordinary forms of neuralgia of the fifth nerve, termed *trigeminal neuralgia*, are often dispersed quickly by the use of electricity; but the more severe forms, such as *tic douloureux*, yield very slowly, if at all, to its use. In the great majority of cases the galvanic current will give the best results. The method of treatment would be to place the positive pole over the point of emergence of the nerve from the skull—supra-orbital, infra-orbital, or mental, according as to whether the first, second or third division, respectively, was involved—and the negative over the nape of the neck, the sitting lasting from eight to ten minutes, the current being mild, 5 to 8 ma. In tic douloureux the current strength may range from 30 to 50 ma.

In those forms of neuralgia associated with general debility, static electricity will usually prove the most serviceable. It may be applied in the form of static insulation, or by means of the spray or the head breeze. When the spray is employed it should be so concentrated as to present the visible bluish discharge; care being observed not to allow sparks. Repeat the treatment in obstinate cases until relief lasts longer, and then as needed until entire recovery.

In those forms of facial neuralgia where the pain is located in a tooth (or in the teeth), the faradic current will sometimes relieve the pain instantly. The current is conducted to the tooth through the dental electrode, and the indifferent pole placed at the nape of the neck. The galvanic current will frequently give relief, the positive pole to the tooth, the negative to some indifferent point.

SCIATICA.

(*Neuralgia of the Sciatic Nerve, Sciatic Neuritis.*)

All affections come under this heading in which the pain is confined to the sciatic nerve and its distribution. There are two types of sciatica—inflammatory (sciatic neuritis) and non-inflammatory (sciatic neuralgia). The first type, sciatic neuritis, is an inflammation of the sheath of the sciatic nerve, and may be caused by exposure to cold, standing in water, sitting on the damp ground, extension of inflammation from other structures, as diseases of the sacrum, periostitis of the ilium, but more especially hip-joint disease. The second type, sciatic neuralgia, may be caused by tumors in the pelvis or along the course of the nerves of the thigh and leg, aneurism, enlarged or varicose veins pressing on the sciatic nerve, accumulation of fæces, or a depressed state of the nervous system. Sciatica may also be due to spinal affection, hysteria and metallic poisoning. Predisposing causes to either affection are gout, rheumatism, syphilis, gonorrhœa, and malaria.

The chief symptom is a pain along the back of the thigh, following the course of the sciatic nerve and radiating down its branches, sometimes even to the heel and the outer surface of the foot. There are certain painful points along the course of the nerve termed puncta dolorosa, which pressed upon develops pain. The principal painful spots are: (1) Just above the hip-joint; (2) at the sciatic notch; (3) about the middle of the thigh; (4) in the popliteal space; (5) at the head of the fibulæ; (6) behind the external malleolus.

The prognosis is as a rule favorable, with the exception of those types due to hip-joint disease, tumors within the pelvis, etc., and even in these cases when the pressure is removed the affection will eventually pass off.

The distinction between a sciatic neuritis and a sciatic neuralgia is sometimes difficult. In sciatic neuritis the pain is

confined more to the track of the nerve and is aggravated by the least movement; while in sciatic neuralgia the pain is referred more to the branches and distribution of the nerve, or darts up and down the trunk, and movement affects it but little, if at all. In sciatic neuritis there may be paresis, or even paralysis, and a slight wasting of the limb; while in sciatic neuralgia these symptoms are absent.

In the electrical treatment of sciatica the best results are obtained from the use of the galvanic current. One electrode, a large, flat one, is placed over the sacrum or lower lumbar vertebræ, while the other is placed over the tender points along the course of the nerve. The position of the poles will vary according as to whether it is a sciatic neuritis or sciatic neuralgia. In sciatic neuritis the positive pole should be placed over the lumbar region, the negative over the track of the inflamed nerve; while in sciatic neuralgia the best results are obtained by placing the negative pole at some indifferent part of the body, the positive over the painful points. The application is made daily or every alternate day, the *seances* lasting from five to ten minutes, the current ranging from 15 to 30 ma., according to the sensations of the patient.

According to Remark it is advisable to include small parts of the nerves in the current, and thus gradually pass along the nerve from the sacrum to the foot—for example, from the sacrum to the sciatic foramen; then from the latter to the popliteal space; finally from this to the ankle or carpus—and allow a stabile application from one to three minutes in each spot.

The faradic current (secondary) will prove beneficial in many cases; one pole applied to a point of the skin where the trunk of the nerve is accessible, the other pole applied to the terminal branches of the nerve, and the action of the current kept up for fifteen or twenty minutes. The pain becomes much less after a time, and a feeling of numbness is felt in the limb. In some cases the faradic wire brush, applied to the dry skin, has been known to permanently relieve the

pain. Sometimes a single treatment with the dry brush dispels the pain completely; at other times the pain returns after a few hours' absence, and the treatment must be repeated. In such cases where the faradic gives temporary relief, if persisted in it will eventually completely cure the case.

Static electricity will often prove of great service in the acute stages where there is considerable tenderness to pressure. Insulate the patient negatively and apply the positive spray over the painful area. In other cases apply a very mild spark to the painful point and to the entire nerve course. It is often beneficial to apply sparks to the spine and even to the opposite limb from the affected one in order to promote general nutrition and advance the improvement.

Very good results are often obtained from the use of electric baths. The ascending direction of the current should be preferred, that is, the positive pole to the feet, or placed over the gluteal region, and the negative between the shoulders.

If all these methods fail, the galvano-puncture may be tried. Dr. W. H. King gives the following method of operating: The anode is usually applied by means of a large electrode over some portion of the nerve. The cathode is attached to a fine needle such as is used for removing hairs, which is insulated within a few millimeters of the point with shellack. This is introduced at several points along the nerve, and a weak current passed for about one minute to each puncture.

LOCOMOTOR ATAXIA.

Locomotor ataxia is a chronic, progressive disease of the spinal cord and peripheral nerves, characterized by incoordination, peculiar lightning-like pains, anæsthesia, and various visceral and trophic symptoms. This disease consists of a degeneration of the nerve-elements (a gradual decay and death of the nerve-fibre and cell), followed by an overgrowth of connective tissue, resulting in sclerosis (hardening) of the posterior columns of the spinal cord; also of the posterior

nerve-root, and frequently the peripheral nerves. The prognosis as regards recovery is as a rule unfavorable.

In electricity we have a most efficient remedy; in fact, no other therapeutic measure equals in any degree the scientific use of electricity in the treatment of this affection. True, electrical treatment has not proved effectual in permanently arresting this disease, but yet, for the relief of some of the symptoms, and especially for the *pains*, electricity should be tried, for it has often afforded much benefit. In many cases the pains and ataxia have been caused to disappear, and the patient to resume a life of comfort and comparative activity. Of especial use is electricity in the initial and ataxic stages. If applied in the earlier stages it may check or at least modify its course. In the later stages electricity is of very little, if any, benefit.

Galvanization has long held the foremost place in the treatment of tabes. The method of applying the electrodes may vary; one electrode (negative) may be placed at the nape of the neck and the other (positive) on the sacrum; or the negative may remain stationary and the positive moved up and down the spine; or the positive electrode may be fixed upon the spine (an electrode 1½ inches wide by 18 inches long), while the negative pole may be placed upon the sternum and moved over the nerves of the extremities. (In all degenerative lesions of the cord the positive pole should be applied over the seat of the lesion—the negative to some indifferent part of the body.) The strength of the current will vary from 10 to 20 ma.; the seance ten minutes twice a week in the beginning and later once a week.

To affect the cord indirectly or reflexly, Rumpf advises placing the faradic anode upon the sternum, while the cathode is applied to the skin of the back and of the lower extremities, until a decided rubefacient effect is established. He claims that the treatment applied in this manner stimulates the sensory nerves of the skin, which reflexly affects the circulation and nutrition of the cord favorably. Rumpf's treat-

ment with the electric brush, by means of the rapidly interrupted faradic current, has proved beneficial in relieving the pains and the ataxia.

In static electricity we have an agent that surpasses either the galvanic or the faradic currents. The patient should be placed upon the insulated platform and heavy sparks (positive) applied up and down the spine; also the cutaneous peripheral nerve-distribution may be excited by means of a fine spark produced by means of the spray or the massage roller.

Static electricity will do more to relieve pain and maintain a degree of comfort than any other agent. Of the value of static electricity in the treatment of locomotor ataxia, Professor Morton says: "A case of locomotor ataxia cannot be said, in the opinion of the writer, to have had the full benefit of what electricity can accomplish until it has been treated by the franklinic current. By this means I have seen the swaying symptoms, the ataxia, the pain, the anæsthetic areas, the bladder and sexual troubles completely disappear, the field of vision to greatly enlarge, and the gait to become normal. I have never known the knee jerk to return, nor have I ever seen what I should regard as a complete cure. But I have seen complete arrest of the disease, lasting for years—and this, too, in the second or ataxic stage. Although a complete cure cannot be promised, nevertheless the patients can be relieved from their distressing pains, and in many instances restored to a fairly natural gait."

The patient should be insulated negatively and heavy positive sparks drawn from the spine and roots of the spinal nerves for three or four minutes; then milder sparks may be drawn from various parts of the body, following down the trunks of the nerves and finally from the bottom of the feet, where the current should be concentrated for two or three minutes. The application to the feet, by its reflex action on the spine, has a beneficial action in relieving the ataxia.

Treatment of the nerve-roots and the peripheral nerves should never be neglected, since they, as well as the posterior

columns, are in many instances the seat of pathological changes. This is best accomplished by applying the sparks as just stated, or by applying the faradic current to the back, and especially to the extremities.

The sinusoidal current will often prove of great value. Its application is simple and controllable, as well as pleasant to the patient. It is administered by means of a "foot plate" and a neck electrode for from five to fifteen minutes every other or every third day for a course of about six weeks. Under its use the lightniug pains cease, the ataxia of gait and station improve and the well-being of the patient is promoted.

SPINAL IRRITATION.

This is a functional disorder characterized by a severe pain, involving a greater or less portion of the spinal column, and associated with this pain there is marked tenderness over the spinous processes of the vertebræ and the adjacent spine.

Of the many affections allied to hysteria, spinal irritation is one of the most prominent, and is often associated with it. When it is simply a lesser symptom of hysteria or nervous exhaustion, it cannot claim a distinct nomenclature, and does not call for special consideration in treatment. When, however, the spinal tenderness and the symptoms that directly flow from it overshadow other accompanying conditions it claims a place as a distinct disease, and should be treated accordingly.

In electricity we have a most efficient remedy. When the galvanic current is used, the spine should be thoroughly galvanized. When the whole cord is to be brought under the influence of the current, one electrode is placed on the upper and the other on the lower portion of the spine; or one electrode is made stationary and the other passed up and down the entire length of the cord by labile applications. Benedict recommends that the positive pole be placed on the spine above the diseased portion of the cord, and that the negative be slowly passed up and down the vertebral sides of the

column. The back is not usually sensitive, and a strong current can be borne without discomfort. Where one or several vertebræ are painful or sensitive to pressure, the treatment should be directed to those parts; or, place the negative pole (a large one) over the abdomen, and apply the positive over all the sensitive points along the spine. General faradization is often a beneficial adjunct to the treatment of this affection.

In static electricity we have an agent which I think will even surpass galvanism. In using this form of electricity we have to be governed by the general condition of the patient. If the case is one of anæmia, the patient should be insulated with the positive pole, and either the static breeze or negative sparks applied up and down the spine. The reverse of the poles in such a case would be followed by an aggravation of the symptoms. In other cases—that is, those that are not anæmic, and especially in cases that are of a very nervous condition—the best results are obtained by negative insulation, with the positive breeze or sparks applied up and down the spine. This has a tendency to reduce the excessive irritability, and in many cases a few applications will relieve the pains.

CHOREA.

Chorea is a functional nervous disorder characterized by irregular spasmodic movements, quickly beginning and quickly ending fibrillary jerks or a fibrillary wavy movement, by inco-ordination of voluntary movements, and often by muscular and mental weakness. The prognosis is, as a rule, favorable.

In electricity we have a most valuable agent in the treatment of chorea. In no diseases are there stronger indications for the use of electricity than in cases of chorea that have assumed a chronic form; in such cases, electricity, in some form, is far superior to any and all other methods of treatment. It cures, almost without an exception, even cases which have resisted all medication. It is of special value in

the treatment of chorea, on account of its *tonic* and *sedative* effects and its power of restoring the *nervous equilibrium.*

Good results have been obtained from the use of the static, the galvanic, and the faradic currents ; but, personally, I have obtained the most brilliant results from the employment of static electricity ; in fact, its effects are often truly surprising. It is unquestionably the most valuable and efficient means of treatment at our disposal. A general improvement in the physical and mental condition of the patient will be observed during treatment, as manifested by an increase in weight, improvement in complexion, a better circulation of blood, greater cheerfulness and mental activity.

Its method of application will vary in different cases. In those cases that are debilitated and anæmic (and the greater majority of cases of chorea are in these conditions) the patient is to be insulated with the positive pole for ten minutes, for its sedative and tonic effect, and then the negative direct breeze is to be applied upon the head and down the spine for five minutes, concluding with the indirect sparks applied along the spine, over the lumbar region, and to the limbs, and, when the patient is a girl, over each ovarian region in front, for four or five minutes. When the patient is very nervous and excitable, and not in an anæmic condition, she is to be insulated with the negative pole instead of the positive. Beneficial results may be obtained by using the galvanic in combination with static electricity.

When using galvanism, the current should be applied either to the entire length of the spine, the positive being placed low down on the nape of the neck, and the negative on the sacral region ; or galvanize the brain by passing the current transversely through the head, and then longitudinally —the positive pole on the forehead and the negative at the occiput ; next give labile applications over the cervical sympathetic with the positive, the negative pole resting over the seventh cervical vertebræ. The strength of the current and its duration of application will vary as to whether the brain

or spine is being treated. When applied about the head, 3 to 5 ma. for three or four minutes; when to the spine, 8 to 10 ma. for ten minutes. It is usually better to galvanize both the brain and spine at the same sitting, allowing three minutes for the brain and seven for the spine.

The faradic current applied in the form of general faradization will prove of special value as a general tonic, and as a sedative to allay irritability and induce sleep. An application of the secondary faradic current to the muscles chiefly affected will in many instances modify the excessive muscular twitchings.

NEURASTHENIA.

Neurasthenia is one of the so-called functional diseases—that is, the pathological alterations are either cellular or vascular in so slight a degree that their exact nature has not yet been determined by the aids to investigation that are at our disposal in our present state of knowledge.

Neurasthenia is due primarily to a leakage or a waste of nervous vitality, either mental or physical. The strain to which the nervous system is subjected, through the requirements of modern times and the general increased pace at which we live, has a tendency to excite and exhaust the brain so that men break down prematurely from overwork and want of rest. The wonder is that more people do not suffer from nervous prostration when we take into consideration the high-pressure living and wear and tear of the present day.

As it is a disease due to nerve-waste, every case should be examined for direct or reflex causes, either mental or physical, for the source of the nerve-waste. After the nerve-waste has been checked, then the problem before us in the treatment of neurasthenia is to find, and to employ the best methods to establish and maintain the highest nutritive activity. The grand function of all electric treatment is to promote nutritive processes; hence its great value in the treatment of neurasthenia.

Electricity should be considered as one of the remedies most to be relied upon in the treatment of neurasthenia, as it is applicable to a greater number of cases than any other one remedy. Tenderness of the spine and various pains in the back and limbs are, as a rule, relieved or dispelled by one or another of the different forms of electricity.

Regarding the choice of electricity, it is impossible to lay down rules that shall govern us in all cases ; sometimes all three forms—galvanism, faradism, and the static current—act equally well. In using galvanism one electrode may be applied to the nape of the neck, and the other over the lumbosacral region, thus including the entire spinal cord. Either the labile or stabile method may be used. If the brain is to be galvanized, one electrode should be placed over the nape of the neck and the other passed over the brow. Mild faradization is sometimes found useful in these cases. Many cases are benefited by general faradization. Rumpf advocates the brushing of large surfaces with the faradic brush.

In the great majority of cases static electricity will prove the most beneficial. It may be given in the form of insulation alone ; or insulation followed by the breeze to the head, or by sparks to the spine. In those conditions where there is a tendency to a passive congestion of the brain the application should be made by means of the point adjusted so as to localize the discharge to the spine, preferably the nape, in order to obtain an influence over the vaso-motor centre. The static breeze, applied to the head, will sometimes relieve depression and headache like magic. Severe peripheral pains and the different neuralgias are, in the majority of cases, relieved by the sparks.

In using static insulation each case will have to be individualized. If the case is in an anæmic and prostrated condition, positive insulation is required ; but if there is a high degree of nervous excitability, which requires something to quiet, negative insulation should be employed. Reversing the polarity in these two cases would cause an aggravation of

their ills instead of relieving them. In all cases the treatment should be begun by means of the convective discharge. It is characteristic of living tissues to respond to stimulation, but that stimulation must not necessarily be applied in the form of profound shocks. Leave the severe measures until later in the treatment of these cases.

In the beginning of the treatment with the static current the earlier seances should preferably not last more than ten minutes, as there is danger of inducing an over-stimulation. This should always be avoided. If it is found that a ten minutes' sitting is well borne, the next sitting may be slightly lengthened, and when a patient's toleration is fully established it may be extended to as much as thirty minutes. Galvanization of the spine, combined with static insulation and sparks, will prove more successful than any other treatment.

HYSTERIA.

Hysteria is a term derived from a Greek word signifying the "womb," from the idea that the disease was due to disorder of the uterine system.

Hysteria is a functional disease of the higher cerebral centers, manifested by derangement of the sensory or motor functions and at times those of the sympathetic system, and is a condition in which volition is depressed and emotions exalted, accompanied by constantly changing symptoms which may simulate any known disease. In hysteria we have what has been called the "mocking-bird" of nerve disease, so that every symptom which may be the result of disease or destruction of the nervous system may be simulated by hysteria. It is the most typical of all the so-called "functional diseases."

Hysteria is simply due to a disordered state of the nervous system, and that disordered state is from a lack of proper amount of nutrition, and lack of proper amount of stamina and resistance power. Now, by increasing the nutrition we build up the system to its normal condition, and thereby give

it its power of resistance and thus cure the case of hysteria. If electricity has any action at all, and if there is any action of it in known electrical therapy, it is in its power to increase the nutrition of the tissues; therefore its great value and its special indication in the treatment of hysteria.

Many of these cases, especially paralysis and contracture, can be relieved almost instantly with the heavy static sparks; the patient being negatively insulated, apply the positive pole to the contracted limb. Ofttimes patients that have had a contractured limb which they have been unable to straighten out or use for weeks or months, after one application to the limbs with the sparks, will throw down their cane and walk out of the room; but, in the majority of cases, the contracture will return as soon as the moral and sensory impressions pass off; by repeated applications, however, this tendency will be overcome.

These are the forms of paralysis "cured" by the long-haired so-called "magic doctors," who, amid the plaudits of a wondering audience (and usually the music of a string band), cause their patients to throw away their crutches and walk off the stage; but they usually, however, have to hunt them up the next morning. Any strong emotional disturbance, as fright, etc., will often dispel this paralysis. In case of fire or a burning house, bed-ridden patients have been known to get up and run out of the house.

Static electricity often gives successful results in the treatment of the sensory as well as the motor symptoms. The sparks should be applied directly to the seat of the pain. Many cases of anæsthesia can be relieved by means of this form of electricity. The anæsthesia will often disappear after each sitting and then return again after various intervals. In the majority of cases, however, where the treatments are persisted in, sensibility is completely and permanently restored.

In many cases the general physical condition needs to be treated as much as, if not more than, the motor and sensory

phenomena. These cases are best treated by static insulation. In using insulation, the question as to whether positive or negative insulation shall be used must be decided by the special indications in each individual case. As a general rule, however, when the patient is anæmic, "run down," positive insulation will be called for, while, on the other hand, if the patient is excessively nervous, negative insulation will give better results. Static insulation with the head breeze, followed by mild sparks, acts as a general tonic and gives a refreshing and invigorating effect.

When using the galvanic current place one pole (usually the negative) on some indifferent part of the body and the other pole (the positive) directly over the painful spot. If the spine is the seat of tenderness, the positive pole should be moved up and down the spine. The various forms of neuralgia yield to the galvanic currents more readily than to the other currents—in fact, many of them being dissipated as if by magic. There is no method of treating hysterical neuralgia that compares with electricity.

In many of the cases of hysteria, where we desire the influence of a constitutional tonic, general faradization will be called for and will often prove more successful than anything else. Anæsthesia will yield more quickly to faradism than to either of the currents. There are several ways of using faradism for this affection, but the application of the wire brush is the most effective, as it causes the most intense stimulation. Dysphagia is best treated by the faradic current; this can be applied externally—an electrode placed on either side of the pharynx—or an internal application may be made by means of a catheter-shaped electrode applied to the constrictors of the pharynx.

Aphonia may often be relieved by a single sitting, but the tendency is for it to return time and again. Either the faradic or static current may be used; if the faradic, place one pole on either side of the pharynx externally; if the static, insulate the patient and apply the sparks mildly.

Contractures are not, as a rule, benefited by electricity; but in many instances faradism applied to the contracted limb will cause it to relax.

WRITER'S CRAMP.

This is a disease characterized by a tonic, spasmodic contraction of certain muscles of the hand and arm when attempting to perform certain movements, as writing, etc. It is met with more frequently in those who are accustomed to a great deal of writing; it is also met with quite frequently in piano-players, violinists, telegraph operators, and seamstresses.

In the earliest stages there is a probability of completely relieving all symptoms and eventually curing the case. In later stages the case may yield to treatment, but relapses are prone to occur, and a cure is exceedingly problematical.

Electricity will prove beneficial in the majority of cases. The galvanic current is the one mainly indicated. Spinal and peripheral galvanization are the proper methods. Place the positive pole over the cervical region and give labile applications over the brachial plexus, and then over the affected muscles with the negative pole. Relatively weak currents should always be employed, in order to avoid exhaustion of the motor apparatus.

Galvanization of the cervical portion of the cord will prove of service in many cases. Place the positive pole on the upper cervical vertebræ and the negative in the stylo-mastoid fossa. The current should be allowed to act from five to ten minutes at a time, and be applied to both sides, if the left hand is also suffering. Peripheral galvanization of the nerves and muscles of the affected arm will also prove beneficial.

Static sparks to the cervical region of the cord and to the affected limb often give immediate, temporary relief. These are generally efficacious in at least aiding, if not effecting, a recovery. Sparks may also be applied to the paralytic parts. The faradic current may be used when the affection is para-

lytic, but the galvanic current is usually more efficacious. Massage and gymnastic exercises should be given in conjunction with the electrical treatment.

WRY-NECK.

This disease consists in a spasm of the neck muscles, by which the head is drawn to one side. The muscles on the side towards which the neck is turned are flabby, and sometimes are atrophied, and on the other side are hard and hypertrophied. The spinal accessory nerve seems to be at fault.

These cases, when of long standing, are very obstinate, but in their earliest stages readily yield to electricity. Galvanization of the atrophied muscles with negative pole, using about five ma. for about five minutes; then faradization of the muscles on the other side, using the fifth cervical for the other pole. Relief may sometimes be effected by galvanizing the sympathetic and brachial plexus. A frequently interrupted current should be used. Strong currents are necessary. Do not fatigue the muscles by lengthy treatments; four or five minutes daily is sufficient. Massage may also be used with electricity to good advantage.

This disease is often confounded with stiff neck, which is caused by rheumatism of the neck, which yields more readily to treatment than does torticollis. Wry-neck in hysterical subjects during the earlier years of menstruation, like the other muscular vagaries to which they are prone, frequently disappears as suddenly and mysteriously as it came.

DYSPEPSIA.

The bane of American life is dyspepsia, which has gained recognition as the American disease. Electricity is of special benefit in the treatment of *atonic* and *irritative* dyspepsia.

Atonic dyspepsia is due to a general lowering of the vital powers—an exhausted condition of the nervous system. Leucorrhœa, menorrhagia, excessive sexual indulgence,

mental or physical overwork, all tend to lower the vitality. It is not uncommon to find anæmia and indigestion closely allied.

Irritative dyspepsia is met with more frequently in those persons addicted to the use of alcoholic liquors or highly seasoned food, or in persons of a gluttonous habit.

In either variety of dyspepsia there is a deficiency in the quantity and quality of the gastric juice, and an abnormal increase of alkaline mucus, which gives rise to fermentation instead of digestion.

In these types of dyspepsia the secondary faradic current is more especially indicated, for it acts more vigorously on the muscles of the stomach and intestines than the other current. It acts beneficially as a form of massage on the deeper tissues. When the faradic current of high tension is employed, the electrode which is used over the region of the stomach is kept in constant motion, so as to avoid those painful muscular contractions that so frequently occur. The other electrode may be placed either over the cervical or lumbar region.

Dyspepsia dependent upon spinal exhaustion will be relieved by a mild galvanic current applied to the spine, one pole being located high up over the superior cervical vertebræ, and the other over the end of the coccyx; also static insulation for ten minutes, followed by the spinal breeze for five minutes, will prove beneficial.

The application of static electricity will prove of great value in that form of dyspepsia known as "nervous dyspepsia." As a rule, the patient should be insulated with the positive pole (as the most of these cases are due to a general debility of both the physical and nervous systems), and mild sparks are applied over the region of the stomach and bowels. It has the effect of correcting any insufficient or perverted innervation of the stomach, and of regulating, first, the action of the glands of the stomach, and, second, the hydrochloric acid in the stomach, lessening it when the quantity is too great, and increasing it when the amount is too little.

Constipation, chronic diarrhœa, jaundice, insomnia, and headache are often associated with dyspepsia, and generally yield to electricity when the treatment for dyspepsia is resorted to.

THE LIVER.

The liver is the largest gland of the body, and its function is an important one. It is a great physiological and chemical storehouse and a center for chemical changes upon which nutrition largely depends. It makes and stores up the glycogen which is to be called into play when heat and muscular energy are required. It secretes the bile and doles it out when it is required to carry on digestion. It destroys the peptones which are poisonous, and, in its conservative way, turns them into glycogen.

One of its special functions is to filter from the blood organic poisons, which have been formed in the alimentary canal during digestion, or which have been introduced into the system from without, that would be poisonous to the system if permitted to enter the general circulation, and return them to the intestinal tract, by means of the gall and by way of the gall duct, to be discharged from the system as effete matter. In fact, it is one of the most important scavengers of the body.

When the functions of this great organ are deranged the following symptoms are present: Headache, a thickly-coated tongue, a bitter taste in the mouth, nausea, heartburn, vomiting, constipation alternating with diarrhœa, skin jaundiced to a more or less degree, and the pain in the back between the shoulder-blades (liver pain); also there are usually considerable pain and tenderness in the hepatic region. In diseases of the liver the portal circulation is disturbed; the flow of blood being interfered with may cause dropsy, piles, or the formation of gallstones, or may cause hemorrhage of the engorged stomach or bowel. The blood represents one-twelfth of the body weight, and normally about one-fourth of it is distributed in the liver.

The morbid conditions of the liver in which electricity will prove beneficial are congestion (enlargement) and cirrhosis. Faradization has long held first place. It increases the circulation of the liver and consequently leads to an increase of the excreted urea. In applying the faradic current to the liver, one pole should be placed over the spine in the lower dorsal region, and the other applied over the region of the liver, even carrying the electrode partially under the ribs.

In many instances, however, where there is a torpid liver associated with a torpid condition of the bowels, the galvanic current seems to give better results than the faradic. The method of treatment is to place one electrode over the back low down on the dorsal spine, at the region where the so-called liver pain is felt, and the other over the anterior part of the liver, pushing it up well under the ribs. The posterior one should be large and connected with the negative pole. The strength of the current should be moderately strong—as strong as the patient can comfortably bear it; the sitting about ten minutes, repeated once or twice a week.

In cirrhosis of the liver place the positive pole of the galvanic current over the upper dorsal region and apply the negative pole—a small one covered with moistened cotton, and upon this add four drops of the tincture of iodine—over the region of the stomach. The negative should be slowly moved over the region of the liver, so as to distribute the iodine, thereby preventing blistering. The seance should last from five to ten minutes; current strength, 10 to 15 ma.

Whenever the liver shows signs of tenderness or softness, the muscular faradic current (medium size coil) should be used for about ten pulsations, or interruptions, and then stop; this will act as a massage. Then faradize the small intestines for about three minutes. These treatments should be given about twice a week until decided improvement, then lengthen time; sitting, ten minutes; current strength, as strong as can be borne.

HEMORRHOIDS.

In the treatment of hemorrhoids by electrolysis Dr. J. B. Bacon advises the use of a long pair of forceps, somewhat similar to urethral forceps, but insulated throughout except half an inch of the tips, with a set-screw on the handle of the instrument. The forceps are connected with the positive pole, and the tumor is seized in such a way as to allow the insulated tips to grasp its base; the negative pole is connected with a needle-holder containing four needles; then inject four drops of a four per cent. solution of cocaine into the tumor, and allow it time to act; the needles are then introduced into the center of the tumor, and a current of from 5 to 10 ma. should be allowed to pass until the hemorrhoid becomes of a whitish-gray color (from two to five minutes), and the result will be the final absorption of the tumor.

The following suggestions, as given by Dr. Bacon, should be followed closely, or the operation may not only prove a failure, but also a source of danger: Give an enema and thoroughly empty the colon before operating. Disinfect the tumor before introducing the needles, and again after the operation. Never use this method in acutely inflamed hemorrhoids. Do not use over one-sixteenth of a grain of cocaine hyperdermically. Always insert the needles into the tumor before the current is turned on, and have the assistant turn the current off before withdrawing the needles. Use a milliamperemeter for measuring the strength of the current, as it is impossible to estimate the varying resistance of the tissues in different cases. The needles may be a direct source of infection in the hands of a careless operator, and they must be boiled before using.

ELECTRICAL TREATMENT OF CONSTIPATION.

The frequent and injudicious use of powerful purgative medicines, and the constant dilatation of the bowel as the result of retained fæces, and the constant use of enemas, have

all a tendency to cause paralysis of the peristaltic movements of the intestinal tract—the result being constipation. A torpid condition of the liver, loss of power in the abdominal muscles, and a protracted diarrhœa may also act as causes. Some of the most obstinate cases of constipation are due to the long-continued use of injections of glycerine. Glycerine has a tendency to leave the rectal membrane in a very dry condition; the same is true of the constant use of injections of water, but not to such a marked degree.

In electricity we have a most efficient remedy for the treatment of this troublesome and obstinate affection. No other single therapeutic measure surpasses its scientific use in this affection. The objects of electricity are: (1) To increase the action of the liver by increasing the arterial, and thus decreasing the venous blood supply; or, in other words, to relieve a torpid condition of the liver. By this means the nutrition of the liver is increased, and as a consequence there is a corresponding increase in its secretions, which aid in the digestive process. (2) To stimulate the muscular tissue and glands of the intestines. It is a physiological law that by increasing the nervous and muscular tissues of any organ you increase the nutrition of that organ, and when you increase the nutrition of any organ that possesses glandular tissue you increase the activity and secretion of these glands.

The above objects are obtained from the use of the galvanic current. We have had better results from the method of applying the galvanic current as given by Dr. W. H. King than from any other form of current or method of application. His method of application and the reasons for it are as follows: "When we come to the first consideration, that of increasing the secretion of the liver, the best results will be attained by placing a large flat electrode over the posterior, and a flat hand electrode over the anterior region of the liver. The direction of the current is of great importance. The positive should be attached to the anterior and the negative to the posterior electrode. When we come to the second part, the stimula-

tion of the intestines, we should reverse the direction of the current. Of course this is perfectly logical, as we wish to concentrate the stimulating catalectrotonic effect of the negative pole on the intestines. The large flat electrode should be moved to the sacral region. The flat hand electrode should be given labile over the abdomen for about three minutes, and then stabile over the sigmoid flexure. When we come to consider the physiology of the sigmoid flexure and rectum in the act of defecation, we would undoubtedly conclude that those parts would be the ones which should be most stimulated. Clinical observation bears out this theory, and it will be impossible to cure an obstinate case of constipation without concentrating the current for a few minutes over these parts. The treatment should be given for twenty-five or thirty minutes, and divided equally between the intestines and liver. The strength of the current will naturally vary with the sensitiveness of the patient, but one should always try to reach 20 ma., and it is unnecessary to go beyond 35 or 40 ma."

In the treatment of constipation with the galvanic current rarely is it necessary to introduce an electrode into the rectum. It is only necessary, as a rule, in those obstinate cases of constipation where the rectal membrane is excessively dry, the result of long-continued use of rectal injections of water, or more especially of glycerine. In such cases it should always be the negative pole that is attached to the rectal electrode.

The faradic current will, in many instances, prove of great service in the treatment of constipation. It is especially useful in those cases where there is loss of power in the abdominal muscles; also in cases associated with atonic dyspepsia. It acts as a vigorous stimulant to the muscular fibers of the intestines. It may be applied by means of the unipolar or bipolar method. In the unipolar method one pole is introduced into the rectum, while the other is applied externally to every part of the abdomen. In the bipolar method both poles are introduced into the rectum by means of a bipolar electrode; care being taken that the metal portions of the

electrode are passed entirely within the sphincters. The strength of the current, when using either method, may be safely left to the sensations of the patient; whatever can be borne without great discomfort is safe to use; also flatulence, colic, etc., are relieved by faradization, one pole being inserted in the rectum and the other moved over the abdomen.

In certain cases of intestinal atony, especially where there is meteorism and tympanitis, the galvanic current will often prove superior to any other remedy. In such cases a rectal electrode (negative) is introduced into the rectum from four to six inches, the other being applied to the abdomen.

INCONTINENCE OF URINE.

The galvanic, faradic, and static currents have all been employed and proven of benefit in this troublesome and ofttimes obstinate affection.

When the galvanic current is used, one of two methods may be employed. The first method (percutaneous method) is to apply the negative pole directly over the region of the bladder, the positive being placed over the cervical or lumbar regions. The second method (direct method) is to place the negative pole in the urethra, the positive just above the symphysis pubis.

When the faradic current is used a slender bougie containing a metallic conductor, which terminates in an olive-shaped tip, is introduced into the urethral canal and placed in contact with the neck of the bladder (but never enter the bladder). The other electrode (a large flat one) is placed upon the lower abominal region. A mild current is then passed for two or three minutes.

In applying either the galvanic or faradic currents the best results are attained by applying the electricity directly to the urethral canal. It is not always necessary to introduce the electrode as far as the neck of the bladder; often if it is introduced only half an inch it will be sufficient. This method so far surpasses the first method (that is, of applying the elec-

tricity extensively over the region of the bladder) that it should be employed almost exclusively. Often three or four treatments by this method, especially with the use of the faradic current, will be sufficient to cure the most obstinate cases.

Many of the large cabinet batteries have a switch connected with the faradic current whereby faradic shocks can be given. In many instances of incontinence an application of from 60 to 100 faradic contacts or shocks, repeated every other or every third day, will entirely cure the case. Pass a curved electrode with a bulbous point directly up to and in direct contact with the neck of the bladder, the other electrode (a large flat one) is placed on the abdomen.

When employing static electricity the patient should be insulated and sparks applied directly to the spine or to the hypogastric regions just over the bladder.

CHRONIC PROSTATITIS.

No condition of disease or mal-nutrition of the genito-urinary tract offers greater opportunities to the electro-therapeutist for brilliant success than chronic prostatitis or prostatic hypertrophy. Every case will receive benefit, and the majority can be cured.

The galvanic is the form of current to depend upon chiefly. The application may be made to the prostate either through the urethra or the rectum. When making the application through the urethra, pass a Newman's olive-shaped sound, properly insulated, and connected with the negative pole, down upon the prostate; the positive pole (a large one) being placed over the lumbar region. In the absence of a Newman's sound, take a full-sized metal bougie and insulate it to within an inch of its vesical end; this will serve the purpose just as well as the other electrode; also a curved silver catheter can be converted into an electrode by covering it with fused shellac or hard rubber, except a small space back of the eye. This catheter electrode will accurately indicate

the neck of the bladder, by means of the flow of urine, and is of special value for old men.

When making the application through the rectum an olive-shaped ball is the active electrode, and should be about the size of the end of the index finger and mounted on an insulated staff. This is pressed against the under surface of the gland. The indifferent pole should be placed upon the abdomen. For most cases of deranged function and incipient enlargements of the prostate, rectal applications of the galvanic current are usually sufficient.

In either method of application the current should be as strong as can be comfortably borne; the seance from eight to fifteen minutes, and repeated not oftener than once a week.

In some cases where the prostate and surrounding structures are very sensitive, good results will be obtained by employing the secondary faradic current twice a week for six or eight treatments before beginning with the galvanic. This will often allay the irritability, and the patient will take more kindly to the galvanic current.

SPERMATORRHEA.

We include in this term all those disorders which are primarily dependent on an abnormal loss of semen; and as its emission from the system in whatever manner effected when excessive is highly pernicious, the nerve centers are deprived of their proper pabulum, are enfeebled for want of nourishment, and the effects produced are ultimately precisely those we see resulting from overwork and excessive mental strain.

A true case of this disease is much less frequent than is generally believed. A discharge from the secretory glands that sometimes occurs without an erection is often taken for seminal discharge. But when a semen discharge occurs involuntarily without an erection, then we have a true case of spermatorrhea.

The faradic current is the one chiefly indicated. Pass the largest urethral sound that can be passed without too much pain. Connect one electrode to the end of this sound, and pass the other electrode over the lumbar and lower dorsal regions of the back, over the perineum and testes, not using a very strong current, repeating twice a week. Either general faradization or central galvanization should be employed at the same sitting; sometimes one form will prove more beneficial than the other; each should be tried.

Static electricity, on account of its general tonic effects, will prove of great service. Insulate the patient negatively, as a rule, and apply the spray or very mild sparks to the lumbar region.

The above line of treatment, in the greater majority of cases, relieves, and if persisted in eventually cures, providing that the condition is not due to rectal irritation, and in that case electricity will do no good unless the cause is removed.

IMPOTENCE.

A case of impotence in an otherwise stout, healthy man is analagous to amenorrhea in a robust, obese woman. It implies a faulty distribution of nerve force and nutrition.

In impotency, electricity is not only strongly indicated, but is undoubtedly more efficacious than any and all other methods of treatment. In the treatment of impotence both the galvanic and the faradic currents are used. When the galvanic current is applied, the negative pole is to be attached to an insulated urethral electrode, which is introduced into the urethra. The positive pole is attached to a large flat electrode, which should be placed over the lumbar region. A mild current should be used for from five to eight minutes, and the sitting repeated once or twice a week. In some cases good results are obtained by simply applying the negative pole to the testes and penis, the positive pole being applied to the back. This method is of especial value in those cases where there is much atrophy of the parts. When

the faradic current is used, one pole may be applied to the back and the other to the glans penis, or place the testes between two wet sponge electrodes.

The galvano-faradic current will, as a rule, produce better results than all other methods combined. Place the electrode that is connected with the negative pole of a galvanic battery over the sacral region, and, with a good-sized electrode, press the testicles and penis firmly against the abdomen, thus bringing the electrode in firm contact with the the under surface of the testicles and penis. This will often cause an erection during the treatment. The strength of current moderate, and passed for six or eight minutes; treatment twice a week at first and later once a week.

Static insulation for ten minutes, followed by mild sparks to the back and perineum four or five minutes, should occasionally be employed. When we bear in mind the number of nerves which center in the perineum, the beneficial reflex effects from so powerful a stimulation can readily be appreciated.

STRICTURE OF THE URETHRA.

There is no one trouble with which men suffer, or of more frequent occurrence, that so baffles the skill of the physician or tries the patience of the sufferer, than stricture of the urethra; and none in which electricity will give more satisfactory results and permanent relief.

Removing a stricture by means of *electrolysis* is not, as many physicians seem to have the impression, a "cauterizing" or "burning out" process. There is no heat, not the slightest elevation of temperature in the electrode; hence there could be no cautery or burning. The process is one solely of chemical decomposition and disintegration of the strictured mass, which passes off as gases, discharges, and even at times of large particles of the strictured mass itself.

For the removal of strictures any good galvanic battery which is steady in its action will suffice. The urethral

electrode consists of a firm sound, insulated with hard-baked rubber. The extremity is a bulb, which is the acting part in contact with the stricture. The principle is to have a working point with the balance of the bougie insulated. There are several varieties of these electric bougies, the Newman sounds being about the best. As to the position of the patient, he may either stand or lie down. If very nervous it will be better for him to lie down, as he will be very likely to have a certain amount of reflex shock. Otherwise, have him stand at your left side with his hand resting upon the back of a chair to support and steady his body.

To determine what sized electrode to use, measure the amount of stenosis of the canal with the bougie a boule or with an ordinary steel sound.* An electrode one or two sizes (three by French scale) larger than the strictured calibre of the urethra will be the proper size to start with. Lubricate this with glycerine—lard, vaseline, and similar agents are not well suited for this purpose, as they act as insulators to a more or less degree. Connect this electrode with the negative pole—the positive being applied to some indifferent part of the body, as the sacrum or the inner part of the thigh. This bougie electrode is then to be introduced into the urethra until the bulb is arrested by the stricture; then the current is to be turned on and increased very slowly and gradually until the patient feels a warm and slightly prickling sensation, the current being measured at the same time, and should range from 2 to 5 ma., according to the sensations of the patient. The operator must keep the bougie steady against the stricture; he will soon find that absorption is taking place, that the stricture yields, enlarges, and the

* The bougie a boule is the best exploring instrument, which transmits to the finger certain sensations which experience soon classifies, and which culminate in a highly tactile expertness. This instrument is made of whalebone, has a small, olive-shaped head and slender neck, which adds to its flexibility. It is used to explore the urethra and find the number, nature and size of the strictures—the real topography. There is no better instrument for this purpose.

instrument slowly advances and passes the obstruction. At times it will fairly jump through the stricture. If there are more strictures than one, the bougie should be guided in the same way until it enters the bladder. Then the electrode is to be withdrawn slowly, and each stricture well worked out, until the first stricture is repassed, when the current is again to be reduced slowly, cell by cell, to zero; and then and not till then is the electrode to be removed. During the whole operation the electrode must be held loosely and gently in its place against the obstruction, all pressure or force being avoided. The bougie will take care of itself, doing its work by the electrolytic action of the current. A seance may last from five to twenty minutes.

Within seven to ten days we may subject the case to another treatment, with larger sized bougies, and continue on until the normal calibre of the urethra has been reached. Strictures that are very near the meatus are, as a rule, the least amenable to treatment; those from two to four inches from the meatus are more readily cured.

The length of time required to cure a stricture will depend upon the condition of the stricture. A slight stricture may be cured in one treatment, but if the urethra is nearly obliterated and there are infiltrations surrounding it, it will take two or three months with weekly treatments. In those cases where the stricture has been cut or badly treated, it will require even a longer time—even a year or more.

The removal of strictures by means of electrolysis has many points of advantage in its favor; the results being more satisfactory and more permanent than when dilatation alone is employed. The advantages of electrolysis over surgical procedures are that, once cured, no relapse takes place; no after treatment with bougies is required; there is no pain, no hemorrhage, no febrile reaction, nor any ill effects following the operation, nor is the patient confined to his bed.

Dr. Newman offers the following suggestions in regard to this method of operating:

1. Before operating, the susceptibility of the patient to the electric current should be ascertained.

2. The problem is to produce absorption, and not cautery; therefore, weak currents at long intervals are best.

3. The best position for the patient to assume during the operation is that which is the most comfortable to him and the operator. It may be either the erect or the recumbent.

4. Anæsthetics are to be avoided, as it is best to have the patient conscious and able to tell how he feels. If, however, the urethral canal is exceptionally sensitive, an injection of a four per cent. solution of cocaine may be used.

5. Care must be taken to keep the electrode in line, so that the point may not deviate and make a false passage.

6. Force must not be used. The bougie must be guided in the most gentle way, and electricity alone be allowed to do the work. Avoid causing hæmorrhage.

7. During one seance two electrodes in succession should never be used.

8. All operations must begin and end while the battery is at zero, increasing and decreasing the current slowly and gradually one cell at a time, avoiding any shock to the patient.

9. It must not be forgotten to stop the current before withdrawing the electrode, otherwise acute pain will be induced in the course of the urethra, which often remains some time.

10. Pain should never be inflicted during electrolysis; therefore it should not be applied when the urethra is in the acute or even subacute inflammatory condition.

11. It is well to leave a little urine in the bladder. It serves to diffuse the stimulus and is more agreeable to the patient than when the bladder is empty.

12. Electrolysis will pass and enlarge any stricture when other instruments or the skill of surgeons fail, which I have often demonstrated.

13. Electrolysis is applicable to all strictures in any part of the urethra.

In addition we would offer the following suggestions :

1. *Always test the polarity before beginning an operation.* The simplest method is to immerse the metallic tip of the conducting cords in water and turn on the current. The tip around which bubbles gather the most quickly is the negative.

2. It is important that the *negative* pole be connected with the urethral electrode, otherwise it will become glued to the tissues so that it cannot be removed without violence, and the cicatrix which forms where the positive has been applied is liable to contract and form a worse stricture than the one it was intended to remove.

3. It is better to measure the distance of the stricture from the meatus before beginning the operation.

4. Select an electrode about three sizes larger than the exploratory sound which passes the stricture ; also in a second operation use an electrode three sizes larger than the one used at the first sitting.

5. Pass the electrode down to the stricture, and when it passes through carefully guide it with the thumb and finger along the canal until it comes to another or, if there be no more, until it enters the bladder.

6. After the bulb passes through a stricture or strictures, it should be withdrawn slowly, and each stricture well worked out—that is, until the bulb will pass and repass the stricture without catching on the edges.

7. If the urethral canal is highly inflamed an operation is contra-indicated until the inflammatory condition subsides. The introduction of bougies every third day annointed with a soothing ointment will aid in allaying the irritation prior to the use of electrolysis. A good soothing ointment for this purpose is Benzoinol ointment. It consists of Oil Eucalyptol ʒj, Benzoinol ℥iv.

8. If there is hemorrhage or discharges following a treatment, another should not be given until such conditions have subsided.

9. It is better to lubricate the sound with glycerine, as vaseline or grease of any kind has a tendency to act as an insulator.

10. The strength of the current should not exceed 5 ma.; in the greater majority of cases 2 or 3 will be sufficient.

11. It is essential to have a milliamperemeter to measure the current correctly.

12. A second sitting should not be sooner than seven to ten days.

13. No other instrument to be introduced into the urethral canal between the treatments.

The entire operation, which rarely exceeds seven minutes in length, is effective and leaves the patient as ready to attend to his daily affairs the moment it is over, and thenceforward, as he was before, and this method would have supplanted the frequently unsatisfactory surgery of urethral stricture long ago if surgeons clearly understood its performance and appreciated its results.

Stricture of the esophagus or of the rectum are treated on the same principle as stricture of the urethra, with the exception that stronger currents (5, 10, 15, and even 20 ma.) will be required and the seances closer (four to seven days).

There is a form of stricture termed spasmodic stricture which simulates in many respects an organic stricture. There are two ways to diagnose a spasmodic stricture: (*a*) When the electrode is placed against the stricture and held there a very short time it gives way easily and permits the instrument to pass by; (*b*) by means of the endoscope, if there is an organic stricture, you can see the cicatrix, but if its of the spasmodic variety it looks as if the blood would drop out of it. Spasmodic strictures must always be treated with the faradic current; galvanism makes the spasm worse.

RHEUMATISM.

There is no one disease for which electricity has been more frequently employed, nor one in which its virtues have been more proclaimed, than rheumatism, among those diseases in which electricity possesses a well recognized and positive value. There are few where it more frequently yields disappointing results than in this condition. The reason for this lies in the fact that a proper discrimination does not enter into the selection of cases.

Acute articular rheumatism is very little benefited by electricity in any form. In the subacute variety, or after the acute symptoms have subsided, much benefit can be derived from the use of electricity. It must be applied in a scientific manner and much patience is required by both patient and physician. It is unreasonable to expect tumors, deposits about joints, and anchylosis to disappear in a short time. Rheumatism is of that class of constitutional diseases having special local manifestations, and therefore demands constitutional as well as local treatment. If this truth is borne in mind, far better results will reward our efforts than if reliance is placed on applications simply to the part affected.

Electricity relieves and cures rheumatism by promoting metabolism and securing prompt and better elimination of the products of combustion. The most important action of electricity in treating rheumatic diseases is due to its effect on nutrition. Local tenderness, pain, swelling, thickening and effusions are combated by local applications, but the general or nutritional action is by far the most important. The most satisfactory results obtained from the use of electricity in the various forms of rheumatism is in that known as *muscular* rheumatism. Electricity acts beneficially in relieving the pain and stiffness of the muscles. All three forms of electricity—galvanic, faradic, and static—are of value in the treatment of this affection, but in the majority

of cases static electricity will prove to be the most efficient of all the electrical methods.

In acute muscular rheumatism, the galvanic current may be used until the swelling and pain have in a great measure disappeared. The positive pole should always be used over the painful area, and, as a rule, weak currents employed; also for effusions into joints the galvanic current is best, and a comparatively strong current should be passed through the joint. Both electrodes may be placed on the joint, or one electrode is placed on some indifferent part of the body, and the other electrode, positive or negative as indicated, is placed on the diseased joint.

The static induced current is of special value in acute muscular rheumatism, its action being almost that of a specific. One pole is applied to some indifferent part of the body and the other directly to the parts affected. The strength of the current being mild, the sitting ten minutes, and repeated every day until improvement, then every other day.

In chronic cases static electricity has given brilliant results, especially where the pain is dull, aching, and very deep-seated, even in repose. The patient should be insulated negatively and the roller electrode, connected with the positive pole, passed over the affected parts for from ten to fifteen minutes.

General faradization or general galvanization may be used either with or without the bath. As a rule, the most satisfactory method of electrical treatment in these cases is general faradization with the descending current—positive on the nape of the neck and the negative applied to the body and limbs. Purely local applications, while not altogether useless, are by no means so efficient as the general method. Applications to the joints alone are unsatisfactory, compared to general methods of treatment.

In the selection of a current for any given case Beard offers the following suggestions: (1) If the pain is of the neuralgic

type and there is considerable tenderness to pressure, especially light pressure, either the galvanic current or the faradic current of high tension (preferably the galvanic) should be chosen. (2) If, however, the pain is dull and aching, seemingly very deep seated, and not aggravated by pressure, static electricity is capable of far greater relief than either of the other forms.

LUMBAGO.

Many cases of lumbago, after suffering for days or even weeks, can be relieved in many instances by a single application of static electricity. As a general rule, the treatment should consist of negative insulation, with application of positive sparks by means of the brass ball electrode; or another method, which is more efficacious, is to pass the roller electrode over the affected parts.

In recent and mild cases the spray will often prove more beneficial than sparks. Insulate patient negatively and apply a concentrated positive breeze to the painful part. Gradually sweep the point nearer the surface so that a succession of spray showers will be thrown upon the muscle. In a few moments increase the intensity of the application so that fine needle sparks mingle with the spray. The effect of this positive spray will immediately be warming, sedative, relaxing, and anodyne to the stiffened and sore muscles. Persist until the patient steps from the platform free from all pain, and able to bend the back and walk about with perfect comfort. Do not stop the treatment until he is entirely free from pain.

The galvanic current will often afford great relief in the acute stage. Apply the positive pole over the seat of the pain, the negative being placed over the abdomen; the strength of current being governed by the feeling of the patient; the duration of the application, eight to ten minutes.

When the faradic current is applied, the secondary current is the one to be selected; one pole applied labile directly to

the muscles affected and the other placed over the abdominal region. Increase the current strength to the point where it gives a marked tingling sensation—never pain—and continue the sitting six or eight minutes, then remove the electrode and have the patient bend in varying positions so as to locate any painful points; then note the location of the painful point and again reapply the current for four or five minutes to that point.

In chronic lumbago where the pains are deep-seated, extending to the spinal articulations, either the static induced or the faradic currents will be especially indicated. Apply one pole directly over the part affected and the other over some indifferent part of the body—the abdomen, or have patient stand bare-footed on a large electrode.

GOITRE.

A goitre is an indolent enlargement of the thyroid gland not dependent upon inflammation or malignant new formations. The causation of this affection is not definitely known. It affects females more than males.

Electricity has been employed with varying success in the treatment of goitre. In some instances no appreciable results whatever attend its administration. As a rule, however, the persistent application of electricity will eventually decrease the size of the goitre, more or less, and not infrequently cause its disappearance altogether.

The method of treatment is to first try external applications of galvanism. Place the positive on the nape of the neck and apply the negative directly to the enlarged glands; increase the current strength at each sitting, as the patient becomes more tolerant to its effects, until a very high intensity is reached, the sitting ten minutes and repeated once or twice a week. Currents may be passed transversely through the goitre for the effect upon the gland.

After the external method has been tried a reasonable length of time, and if there is no appreciable diminution in

size, it is proper to resort to puncture. In employing the puncture method, strict antiseptic precautions must be observed and the puncture is made with a surgeon's needle insulated with several coats of collodion. The puncture should be made, if possible, low down the isthmus, and during the introduction of the needle the patient should be directed to swallow so that puncture of the larynx may be avoided. The subsequent punctures are all made at the same spot. Insert two or more needles deeply into the substance of the gland. The needles must be thoroughly insulated to within one-quarter of an inch of their points and connected with the negative pole, the positive being placed on the nape of the neck. Then allow a current of from 5 to 10 ma. to pass for five minutes. These treatments not to be repeated until all inflammatory reaction has subsided.

The treatment of goitre must be patiently persisted in, and will, in the majority of cases, have to be continued for several months, and, in some cases, even years.

EXOPHTHALMIC GOITRE.

Exophthalmic goitre is a chronic neurosis characterized by prominence of the eyeballs, enlargement of the thyroid gland, and an irregular and rapid heart-beat.

Electricity has proved of more service than any other measure; in fact, it is about the only agent that seems to have any effect upon this obstinate affection. While the enlargement of the thyroid gland and the exophthalmia does not by any means always disappear, the violent palpitation which constitutes the most distressing symptom is decidedly and permanently alleviated. The pulse rate may be reduced in frequency from 20 to 30 beats per minute; the enlargement of the thyroid greatly diminished, and the nervous condition of the patients very much improved.

In exophthalmic goitre, galvanization of the sympathetic and pneumo-gastric, combined with passing the current through the nerves on each side of the neck, is the indicated

treatment. Place the positive electrode low down on the nape of the neck and apply the negative to the side of the neck, from the mastoid process to the clavicle—the two sides of the neck should be treated alternately; the current strength mild, 2 to 3 ma., and continued for four or five minutes. Then the negative pole is to be applied to the pit of the stomach (the positive remaining stabile where first placed), and the current strength increased to 15 to 20 ma., or just short of pain, and allowed to pass five or six minutes. This method of application should be varied occasionally by applying the negative directly to the enlarged thyroid gland, the positive on the nape of the neck, and the current strength as strong as the patient can comfortably bear—20 to 25 ma.

Erb has tried the application of a very mild current to the eyes; one pole was placed on the closed eye, and the other on the back of the neck, and later the poles were placed upon the temple. Transverse currents have been passed through the goitre for a direct effect upon it.

Electrical treatment should be applied once or twice a week for three or four months, and then at intervals for six or eight months longer.

LATERAL CURVATURE OF THE SPINE.

Spinal curvature is due, in the greater majority of cases, to a weakening of the muscles of the spine and back which act as a support in keeping the spinal column and back in an erect position. Many cases of lateral curvature of the spine can be successfully treated without mechanical appliances (braces, jackets, etc.), by the use of electricity. In lateral curvature, then, the object would be to strengthen the muscles by stimulating them with electricity. For instance, if the spinal column curved to the left, it would be the muscles on the right side only of the column that should be treated. Those on the left side should be left severely alone, for their power already is too great, and any stimulation of them would render the deformity greater.

The principal muscles to be acted upon would be the *trapezius* and the *latissimus dorsi*. The motor points of these muscles, as determined by Dr. W. F. Robinson, are as follows: The trapezius has two motor points, each located about one inch from the median line. The upper one is located at the point where the back runs into the neck. The lower one will be found just opposite the spine of the scapula when the arm is allowed to hang down by the side. There is possibly a third point a trifle farther from the median line than the two just mentioned and about opposite the lower angle of the scapula. The motor point of the latissimus dorsi will be found about two inches below the lower angle of the scapula and three inches from the median line. These are the points, then, to which the faradic or static induced currents are to be applied to obtain contractions of the muscles which they represent.

In a case of spinal curvature in which the curve was continuous from the cervical to the lumbar region (spinal lateral curvature), and if the spine curved toward the left side, the trapezius and latissimus dorsi muscles of the right would be treated; but in a double curvature of the spine, say the spine curved to the left in the lumbar region and to the right in the dorsal region, the latissimus dorsi of the right side and the trapezius of the left side should be stimulated.

The galvanic, faradic, or static induced current may be employed. In applying the galvanic current it should be applied not only to the motor points, but also to the whole extent of the muscle so as to increase the nutrition. The static induced current is, as a rule, to be preferred to the faradic, as it is a more powerful tonic to the weakened muscles and has the advantage that there is no pain accompanying its application.

SEPTIC ULCERS AND WOUNDS.

Electro-sterilization, that is, sterilization of septic ulcers, wounds or surfaces by means of electrolysis, is the safest and quickest specific known. The current decomposes all the imperfect materials and changes them into some other non-poisonous compound, thereby relieving the system of poisonous products; and as a result of this electro-chemical action microscopical crevices which contain septic matter, and which could not be reached by means of the ordinary antiseptic solutions, etc., are cleansed of all bacilli and pus cells. This line of treatment, in addition to sterilizing the parts affected, increases the activity of the circulation of these parts, thereby promoting the formation of healthy granulations, and later cicatrization.

Electro-sterilization is accomplished by placing the affected part of the body in a vessel (porcelain, wood or glass), filled with a saline solution, and in this solution is placed an electrode connected with the negative pole. (When it is impracticable to place the affected part in a vessel, as above described, cover the negative electrode with absorbent cotton or sponge, saturate it with the saline solution and apply it to the part to be acted upon.) The positive pole may be placed upon any convenient part of the body. The strength of the current should average about 5 ma. to every square inch of surface to be sterilized, and continued at least half an hour; after that time the polarity should be reversed for five minutes in order to set free the chlorine which will again react on all the external and internal exposed surface. After such treatment a protective dressing of a simple kind is necessary to keep the parts from further infection. The treatments can be repeated as often as necessary until a healthy cicatrization ensues.

Electro-sterilization is highly recommended as a prime antidote to all kinds of stings, dog bites, or in fact venomous

wounds produced by serpents of all kinds. In such cases, however, the current should be applied for a much longer time than for ordinary cases, as ulcers, etc. There are, in fact, no contra-indications for this treatment by electrical sterilization to any class of infected wounds and skin diseases presented to surgery.

SPRAINS.

A sprain is usually a laceration of the capsular or lateral ligaments, with or without ruptured tendons, torn muscles, contusion or laceration of the synovial membrane. Electrical massage with the static roller meets all the indications for the successful treatment of these injuries more perfectly than all other means combined. Its method of application is as follows: Seat the patient on the platform insulated negatively, wrap the foot and ankle in a woolen cloth, and apply the roller (attached by the chain to the positive pole) to the foot, ankle, and leg for ten or fifteen minutes; treatment to be repeated every day until decided improvement, then lengthen the interval. Often, even in the most serious forms of sprains, after five or six treatments, the patient can resume his business with little or no inconvenience.

GLANDULAR SWELLINGS.

There is no treatment that will so quickly disperse a swelling or remove by absorption an enlarged gland as electricity, if properly applied. Especially is this true of that type of tumors of the breast (non-malignant), which appear so frequently in females. Time and again I have seen such a tumor, as large as an English walnut or even larger, disappear entirely after three or four treatments. The galvanic current should be used in all cases. The negative pole should be applied to the affected part, and currents of moderate strength (6 or 8 amp.) applied five minutes daily. In treating enlarged glands, if the negative sponge be thoroughly moistened with tincture of iodine, it will greatly hasten absorption.

Almost every case can be prevented from coming to suppuration if this treatment is employed. From 6 to 8 ma. of current may be used.

CARBUNCLES AND FURUNCLES.

These may be dissipated in their earlier stages by applying the negative electrode upon them and the positive at some indifferent point. The static sparks, however, surpass any other form of treatment, electrical or otherwise, in the treatment of these painful affections. If taken in their earlier stages, and even after being well developed, a single application of the static sparks will often cause them to wither up and disappear within forty-eight hours. The patient should be insulated and positive sparks applied directly to the carbuncle or furuncle.

VARICOSE ULCERS.

In the treatment of these troublesome conditions electricity will often afford material benefit. Both the galvanic and static currents will give aid. For the relief of pain and other distressing symptoms insulate the patient negatively and apply the positive breeze over the affected area. To affect the local nutrition and thereby hasten resolution, apply the mild sparks around the ulcer (never to the ulcer); also apply the negative pole of the galvanic current to the parts surrounding the ulcer, the positive on some indifferent part of the body—usually on the same limb as the ulcer but some distance above it.

CORNEAL OPACITIES.

The galvanic current is of valuable service in the treatment and removal of corneal opacities. The negative pole is applied to the eye by means of a small silver rod with rounded end. The positive pole, a sponge covered electrode,

may be applied either to the other cheek or to the nape of the neck. The current should be very mild, one-fourth ma., and never exceed one-half. The eye is cocainized, and the silver rod is rubbed lightly over the opacity for about one minute. The improvement is due partially to the direct irritation of the cornea caused by the current, partially to the improved nutrition, but chiefly to electrolysis. Often by this line of treatment quite large opacities may be made to clear up almost if not entirely.

VOMITING.

Obstinate vomiting from functional causes can often be promptly relieved by the judicious use of electricity. Both the galvanic and faradic currents have been employed with beneficial results. When the faradic current is employed, place one pole over the pit of the stomach and the other over the lower dorsal region; when the galvanic current is used, place the negative pole over the pit of the stomach and the positive over the nape of the neck. If, however, the vomiting is due to an organic lesion, it will seldom receive more than temporary benefit.

CYSTITIS.

The bladder, after being emptied, is partially filled with warm water and an electrode is introduced and connected with the negative pole of the galvanic current; a broad flat electrode applied over the bladder or sacrum is connected with the positive. The current should be very mild (3 to 5 ma.) and the sitting from three to five minutes.

FACIAL BLEMISHES.

The employment of electricity (only the galvanic current can be used) in the removal of superfluous hairs, moles, warts, corns and small growths is so simple and is attended with so little danger, where proper care is observed, that physicians

should not allow their patrons to go through life carrying unsightly marks that are often a source of great humiliation to them.

The general practitioner, as a rule, seems to have the idea that it requires special batteries, instruments, needles, etc., to perform this work ; this, however, is not the case. Of course where large areas of skin surface have to be destroyed, as in certain forms of nævi, it is better that such cases be sent to a specialist.

For the removal of the majority of these facial blemishes, any good office galvanic battery will answer the purpose ; and as for needles, in most instances any good steel needle will be sufficient. The needle employed in removing hairs should never be sharp, but always blunt and rounded, for a sharp needle would, in many cases, penetrate the walls of the follicle, thus allowing the current to wander into the tissues far from the point to be electrolyzed. The needle employed in removing growths should be sharp-pointed and flat.

The needle should *always* be attached to the *negative* pole. The positive or indifferent electrode may be applied to the body either near to or at some distance from the point of the electrolysis. Usually, however, the best method of applying the indifferent or positive electrode (a thin sheet of copper, 4x6 inches, with a binding post to attach the cord) is to have it lying in the lap of the patient, and when it is desired to complete the circuit have the patient lay the hand upon it. By this method the strength of the current can be increased or diminished by having the patient press lightly or strongly on the electrode, or by bringing more or less of the surface of the hand in contact with the electrode. In this way the patient can render great assistance to the operator. Before the needle is removed the patient is requested to remove the hand from the electrode. This method obviates the necessity of having to always reduce the current to zero before removing the needle ; also the likelihood of producing a slight

shock if any current is on, when introducing or removing the needle.

By the employment of electrolysis in removing facial blemishes, the scars, if any, gradually fade out, to a more or less extent, in the course of six or twelve months. In those cases where large growths are removed, and scars are unavoidable, we have the satisfaction of knowing that by this method they will be less marked and will fade out more rapidly than when removed by any other means.

SUPERFLUOUS HAIRS.

The positive electrode having been laid in the patient's lap, to be pressed upon by the hand of the patient whenever the operator may so direct, and the negative having been attached to the needle, the operator grasps a hair with a small pair of forceps and makes slight traction on it, thereby bringing into view more plainly the point at which the hair emerges from the skin and making it easier for him to introduce the needle. Then, after having thrown into the circuit from three to five cells, the operator passes the needle down along the side of the hair shaft (gently following the direction of the hair as it emerges from the skin) through the tissues to the papilla at the bottom of the hair follicle—indicated to the operator by the needle meeting with a slight obstruction; then the circuit is completed by having the patient place the hand on the positive electrode in her lap. If the current is of sufficient strength, in the course of five or ten seconds bubbles of gas will appear around the needle. After fifteen or twenty seconds slight traction is to be made upon the hair, but if it does not yield to gentle traction continue the current a little longer, and as soon as electrolysis is complete the hair will come away, bulb and all. Care must be observed, however, not to employ too much force or the hair may be pulled out before electrolysis has destroyed the papilla, and as a consequence of this a new hair would grow again from the site of the old one, within four to six weeks.

In case the hair has been accidentally pulled out, insert the needle, if possible, into the follicle and complete the destruction of the papilla.

It is often the case, even though you feel sure that the needle has gone to the bottom of the follicle, and yet the hair is a long time in coming out, that it will be better to remove the needle and put it in at the other side of the follicle, for the action seems to be quicker and the result more apt to be permanent.

In some cases the hair remains so firmly fixed that it will not yield to an ordinary treatment; in such a case pull out the hair, then pass the needle down to the bottom of the follicle and destroy the papilla. It is not always possible to pass the needle directly into the papilla, but even when it comes very near it the hair bulb will be destroyed and the hair will never be reproduced.

The introduction of the needle to the depth of the follicle is not attended with any pain, provided that there is no connection with the battery, or that the needle does not pierce the follicle. There is generally but very little pain, usually only a slight burning sensation, attending the operation for the removal of hairs. Always use a mild current; a strong current or a current continued too long will leave a visible scar. In the majority of cases no noticeable scar remains, or if so, it will gradually fade out and become of similar color to the surrounding skin usually within from three to six months. A milliampere-meter is of very little service, as the operator must watch the point at which electrolysis is taking place and be governed thereby.

In the removal of a large number of hairs, a certain proportion of the work has to be gone over a second, and even a third time. From twenty to thirty hairs may be removed at one sitting, and never more than fifty, as it becomes too trying, particularly upon the eyes. A magnifying glass may be used, if desired, the most practicable being the jewelers' glass, because held by the eye unassisted. Two hairs in close

proximity to each other should not be removed at one sitting, as it would be likely to produce too much electrolysis of the the tissues at that point, and a scar would be the result.

Always introduce the needle before the circuit is completed, and have the patient remove her hand from the electrode in her lap before drawing away the needle, thereby avoiding the liability to slight shock. In every case an absolute promise can be given that eventually every hair can be permanently removed.

MOLES.

If the patient is nervous, and especially in women and children, use cocaine locally, either externally or subcutaneously. A sharp-pointed, flat needle connected with the negative pole (do not attach the needle to the positive pole) is made to transfix the growth at its base, on a level with the skin, or even well under the base of the growth so as to be sure to get it all. The circuit is completed by having the patient place the hand on the positive electrode, or the positive electrode may be applied to any indifferent part of the body. Then turn on the current gradually until minute bubbles appear around the needle; let an even current flow from three to ten minutes, according to the density and the extent of the work to be done. Shut off the current, withdraw the needle, re-introduce it at right angles to its previous position, and turn on the current as before. If carefully done, the growth blanches at once, turns black in a few days, desiccates and falls off, leaving a healthy surface that heals usually without a scar. The only dressing needed is an ointment of the yellow oxide of mercury. Always allow nature to cast off blackened tissue. If the growth is a small one, one operation may be sufficient to destroy it; but when the growth is a large one, the treatment may have to be repeated in from ten to thirty days.

Whenever hairs complicate these growths, the hairs should be permanently removed before attempting the removal of

the mole. Ofttimes the removal of the hairs has been found sufficient to cause the disappearance of the growth.

The removal of small growths, such as moles, warts, corns, etc., is quick, safe, almost painless, aseptic, bloodless, leaves very little or no scar and is the ideal and most rational method.

NÆVI OR BIRTH-MARKS.

By means of electricity birth-marks can be successfully removed. The object to be aimed at in the electrolysis of nævi is to carry the destructive action just so far as to coagulate the blood and break up the blood-vessels without producing a general necrosis and sloughing of the whole. When the nævus is entirely subcutaneous, it can be destroyed without leaving any marked scar; but when it involves the whole thickness of the skin, there will be more or less sloughing, but the scars are less extensive than if the nævus had been removed by surgical methods.

One of two methods may be used, namely, *unipolar*, where one electrode is attached to the needle or needles in the tumor, the other being applied on some indifferent part; *bipolar*, where the needles from both electrodes are in the tumor.

In removing birth-marks it is well to spray the parts with ether so that the insertion of the needles is less painful. Beard and Rockwell state that a mixture of ether and carbolic acid in equal parts has a positively benumbing effect upon the skin where applied. The mixture can be localized upon a very small spot; the benumbing effect begins to be felt in less than five minutes.

It is usually better to operate upon the nævi as early as possible in young children.

POWDER STAINS.

For the removal of powder stains electrolysis is probably the best means we have. Of course, if the patient is seen immediately after the accident, we should try and pick out

all the grains we can. Soon the powder disintegrates, and the skin is stained just as it is stained by India-ink in tattooing. If each black dot is entered with the needle (needle attached to the negative pole), and the current passed as in the destruction of superfluous hairs, we will succeed in course of time in destroying all the powder marks, and substituting for them minute white cicatrices that are very much less noticeable than are the powder stains; but we may rest with the assurance that even these will in time fade out to a more or less extent. If tattoo marks are also in dots, they can be destroyed in the same way. The absolute controllability of electrolytic action makes it preëminently more fit than any other destructive agent for the removal of these deforming stains.

ELECTRIC BATHS.

Galvanic or Faradic.

Electric bathtubs may be constructed of metal, wood or porcelain. The porcelain is far superior to either of the other varieties, although by coating the wood with white non-metallic enamel it serves almost as well. If the tub is of metal, a lath-work of wood must be placed in the bottom and on the sides, so as to prevent the patient from coming in contact with the metal.

The method of applying the current will vary with the construction of the tub. If the tub is of metal it will form one of the electrodes, one pole of the battery being attached to it. The tub would act as the passive electrode, the other electrode (the active) being connected with a large sponge and applied to any part of the body not under the water. If the tub is made of non-conducting material (wood or porcelain), one electrode is placed on the nape of the neck, between the shoulders, or on the back, and the other, in the form of a foot-plate, at the end of the tub against which the feet rest; by this arrangement the current is passed lengthwise through the body. The water should be deep enough in the tub

to cover the patient's body entirely—the head being elevated. The water should be of a temperature ranging from 98° F. to 100° F. If, while taking the bath, the patient complains of a throbbing sensation or fullness of the head, place cold cloths on the head. If the patient complains of faintness, the current will have to be lessened or turned off entirely and the treatment suspended for that time.

An electric bath must not be taken too soon after a full meal. After taking a bath the patient should rest fifteen or twenty minutes before going out into the open air. The time required for giving the bath will vary from fifteen to twenty minutes. The total strength of current employed when galvanism is used will be about 200 ma. Only about one-eighth of this passes through the patient, the rest passing through the water.

An electric bath is especially useful in the treatment of morbid conditions which affect the whole constitution. It is especially useful in the treatment of chronic rheumatoid arthritis. The natural tendency of this disease is almost always from bad to worse, but even in the worst cases persistent treatment with the electric bath, combined with passive movements, will result in some improvement.

Lateral sclerosis is another affection in which the electric bath is especially useful. The method of applying it in this affection is as follows: The *positive* pole is *always* placed at the *head*, so that the current enters the spinal cord between the shoulders. The current seems to have some specific action on the cord and tends to reduce the reflex excitability. Under this treatment the spasmodic gait is improved and the tendency to tonic spasms decreased. A bath should be given every other or every third day till twelve or fifteen have been given.

The electric bath is sometimes useful in the treatment of mercurial and lead tremors. It will prove of great benefit in certain forms of cardiac affections. It stimulates the nerves and facilitates the action of the heart in such a way as to

enable the latter to gain in nutrition. The effects are not temporary, but permanent; the symptoms losing their acute character, and the patient experiencing a great sense of well-being. The baths are, of course, only applicable in cases where the heart is not degenerated, and in which there is only cardiac cachexia. Electric baths are invaluable in restoring the constitutional vigor after it has been impaired by excesses of any kind.

The bath is advantageously employed where the general applications of either the galvanic or faradic currents are to be made. By some it is claimed that it is the most thorough way of applying general galvanization or general faradization. Electrilization is certainly more general by this method than by any other, but whether it is more effective or even as effective as when the electrodes are applied directly to the body is a question of doubt.

THE FARADIC DOUCHE.

The douche proper, hot or cold, is used as the rheophore or conductor to carry the faradic current by which its efficiency is greatly augmented ; a large plate electrode is applied as the indifferent pole to a near surface of the body, and a douche or spray, of proper temperature, is thrown from the fluid-carrying rheophore at a distance of six to twelve inches upon the part to be reached. It is especially useful as a general application in neurasthenic cases and spinal weakness.

THE ELECTRO-VAPOR BATH.

The electro-thermal bath is given in a cabinet, specially designed for the purpose, and constructed to suit the conveniences of the physician. In the cabinet, the patient is subjected to the influence of hot air or vapor, and to the electric current chosen for the treatment. The patient sits within this cabinet, nothing but his head without. Around his neck are placed warm towels to prevent the escape of the steam or hot air. This steam or hot air is generated within

the cabinet by means of an alcohol lamp placed beneath the stool upon which the patient is seated, or carried into the cabinet by means of an apparatus connected with a boiler or heating apparatus outside. The vapor may be used at a temperature varying from 90° F. to 100° F. The hot air can be borne up to 130° F. The patient receives the benefits of either the Russian or Turkish baths, and is, at the same time, submitted to the influence of the physiological and therapeutic properties of the electric current used.

The term "hot air or electric vapor bath" is misleading, for, although the patient is enveloped with hot air or vapor, the current can only be conveyed to him by means of contact with the electrodes. One pole being connected with the stool upon which the patient is seated, the other pole with special electrodes is applied to different parts of the body. A hot air or vapor electric bath is, therefore, nothing more than the application of electricity to a patient whose skin is rendered a better conductor through the warmth and perspiration that is induced.

One advantage of the electro-vapor bath is that the resistance of the skin is very markedly diminished and stronger electric currents may be applied to the body without any sensation of pain. The electric currents in their turn counteract whatever depressing effects the vapor bath might cause, producing a feeling of buoyancy and energy; also general galvanization and general faradization are much easier to employ, because the patient is undressed, the electrodes are necessarily moist and the resistance of the skin is reduced to a minimum. The patient receives the benefit of general and local treatment, easily and conveniently applied.

A hot air or vapor electric bath occupies fifteen or twenty minutes; at the conclusion the patient should be cooled down by a shower bath. These baths are especially useful in chronic rheumatism, stiffness of the joints and skin diseases.

THE ELECTRICAL TREATMENT OF THE DISEASES OF WOMEN.

The most marked and rapid advances in electro-therapeutics have been made in the treatment of the diseases of the female pelvis. Nothing else can compare with its usefulness in this affection. We have in electricity an agent capable of exerting a remedial influence over almost every form of disease of the pelvic organs, an agent possessing an infinite capacity for modification, according to the method of its application.

Electricity skillfully and patiently applied deserves to remain at the head of conservative gynecological therapeutics. In electricity we have an agent which, in many cases, will accomplish a cure by less heroic means, more safely, and with less suffering, than can be done by any other method.

In cases where it is of no value as a curative agent it may be of the greatest help in clearing up a doubtful diagnosis and settling the question as to whether or not an operation is desirable. In this connection, electro-therapeutics is not hostile to surgery, but, on the contrary, is a most important adjunct to it by pointing out clearly the indications for operation, and also by completing what the latter has begun, but is not always able to finish—the entire restoration of the patient to health. The great change which takes place in some patients in a comparatively short time is almost incredible. In many others the effects are not so striking, but sooner or later, through care and perseverance, the results for which we are laboring will surely come.

We desire to enter an earnest plea for greater conservation and more careful consideration of other means, less brilliant, perhaps, but equally as efficacious as the knife and curette. The prevalent customary treatment is surgical for the female organs, and non-surgical for the male. Conservation is no more important in the one than in the other. To cure the

ill-health of a woman whose appendages are diseased, or to relieve her from suffering, a surgical operation is by no means always necessary. We do not contend that operations are never necessary, but we do claim that they are performed too frequently without previous efforts to overcome the apparent necessity for a radical operation by every known means. Too often has it been the case that the ovaries have been removed for vague, nervous troubles, when, in fact, they were not diseased, the true cause being an irritation at some other point. Many a woman complaining of pains down the limbs, in the abdomen, and in the back, and who was suffering from general nervous prostration, has had her case diagnosed "ovarian disease," and those inoffensive organs forthwith removed; and yet this measure bringing no relief whatever, on account of the true source of the trouble—a catarrhal endometritis—being entirely overlooked. An endometritis is frequently a source of as much suffering as diseased appendages, and will persist and give trouble after the appendages are removed. By curing the endometritis we strike at the root of the evil and not that irrational method of removing the appendages, the effects or result of the initial disease, for, as a rule, disease of the tubes are only extensions of a previous diseased condition of the uterus.

The after-effects of removal of the ovaries, tubes, or of the womb are often most deplorable. In the first place the patient is unsexed; she becomes prematurely old; often becomes fat, irritable, indolent and dissatisfied; an artificial menopause has been induced, and she will be subjected to all the annoyances of the change of life, such as flashes of heat, skin tinglings, numbness of extremities, etc., but of much longer duration than when the change of life comes on naturally. Mental disturbance may be traced directly to the removal of the ovaries. This is manifested by morbid brooding, of low spirits, of melancholy, of suicidal impulses, and even by insanity. Glavaecke, who has made extensive researches on this point, goes as far as to state that "in

almost all cases the mind becomes more or less affected, and not infrequently melancholia results." Keith has stated that ten per cent. of his patients who recover from hysterectomy subsequently suffer from melancholia or from other forms of mental disease.

A great many women are now going about without ovaries who might still be in possession of them, and yet be restored to a healthy condition, if it had not been for the one-sided idea that whenever there are any menstrual disorders or obscure and vague pains the offending organs—the ovaries—should forthwith be removed, as they are of no further use.

On this point Dr. Paul F. Munde says: "I am convinced that in the past many uterine appendages have been removed which, with a little patience and perseverance on the part of the physician and the patient, could have been saved. I see every year several hundred cases at least of this disease, and if I look back during the past fifteen years I may well say that I have seen at least from two to three thousand women suffering from acute, sub-acute, and chronic inflammation of the uterine appendages. It would not have strained my conscience if I had operated on, we will say, one-half of these cases, because in many of them the appendages were undoubtedly inflamed, adherent and more or less enlarged; but I can say, and I believe with all due modesty, that I am proud of having operated only on sixty-three such patients, two of whom died, the rest making an uneventful recovery. I wish I could say as much of the ultimate results of the operation. In eight, menstruation persisted with increased intensity for from two to three years after the operation, and in a larger number of cases the pains for which the operation was performed continued with almost no improvement." Further he says: "I have seen a tube which was the size of a small banana gradually diminish, shrivel, and entirely disappear after several months of treatment."

On this same subject Dr. C. T. Hood says: "To-day the ideal treatment of pelvic diseases of women is surgical inter-

ference. The physician who cannot count his operations upon the uterus by the score, and his laparotomies by the dozen, is not looked upon as a very high authority in this department. So popular has the procedure become that many cases of slight irritation and congestion of the ovaries are operated upon; the ovaries removed, the result is premature old age, and often only temporary relief from pain. I do not wish to deride or belittle in any way the achievements of modern antiseptic abdominal surgery. Brilliant results have been obtained and wonderful cures wrought by the skillful operator, but abdominal surgery has reached its present degree of perfection at the cost of many lives, while hundreds of women have become prematurely old and their usefulness interfered with in a great measure in order that some ambitious operator might perform a laparotomy."

Too much praise cannot be given to the great achievements of abdominal surgery; but to neglect the application of a conservative procedure as well as curative one to a diseased or functionally-altered organ, to consider only the possibility of surgical operation by removal of the organ and suppression of its function, is to entirely ignore the true spirit of medicine and to lose sight of its essential end, to cure.

PELVIC EXUDATIONS.

Under this heading are comprised all those post-inflammatory pelvic deposits the result of a previous acute pelvic inflammation, such as inflammation of the ovaries, tubes, broad ligaments, etc. It is often impossible clinically to separate the results of inflammation involving the different structures, and declare that the condition is due to the one or the other independently, and such a distinction, in so far as the treatment is concerned, is quite unnecessary.

For the removal of pelvic exudations due to inflammatory action, no line of treatment will in any wise equal electricity. This includes all cases, from the simple thickening of one or

both broad ligaments to complete fixation of all the organs of the pelvis, with a thick unyielding exudate matting everything together.

The benefits derived from the employment of electricity in the treatment of the various complaints due to *pelvic exudations* will be of so marked a character, and the patient so treated will experience such a decided relief, that no physician should fail to give them the benefits of its advantages. The exudate will gradually but perceptibly disappear, the pain from pressure upon nerve fibers and nerve points will rapidly diminish, sympathetic disturbances will be relieved, displacements caused by contracting bands will gradually give way, and the general mobility of the pelvic organs will return, while coincidently the general health is restored from the effects of the electricity on the general system.

Recent adhesions and exudations that have not become thoroughly organized can be quickly and surely removed, but where they have remained for a long time and have become organized the prognosis is less favorable; but by persistent treatment, the greater majority can be eventually made to disappear. In some cases it will take time and patience before we get any noticeable results, but when we consider the importance of the results we should not be impatient; other cases are quickly cured symptomatically as if by magic.

A point that is well to remember in the treatment of these morbid conditions is that the symptoms are relieved much more readily than the pathological condition is cured. Consequently a patient should be made aware of the fact that because she has been relieved quickly of the pain and distress which resulted from the pressure of the exudation, the treatment must still be persisted in until all deposits have been entirely reabsorbed, or the pain will eventually surely return.

A fact that must be remembered is that all acute inflammation, except secondary points arising from irritation of already hardened exudates, should have disappeared in these cases before treatment, according to the method given below, is instituted.

The galvanic is the form of current to be relied upon chiefly for the removal of pelvic deposits. Its method of application is as follows: Place one pole, a very large one, over the abdomen; the other is to be applied either intra-uterine or intra-vaginal. If there is no disturbance produced by the introduction of a uterine electrode, or if the exudated mass is intimately connected with the uterus, and there is also a metritis and endometritis, it is advisable to make the application to the uterine canal. In the majority of cases, however, a vaginal electrode will be preferable. When the positive pole is employed, the carbon ball, clay-covered vaginal electrode should be used. A good one for the negative is the metal ball electrode, the metal part being wrapped with moist absorbent cotton. The object must be, in applying the electrodes, to include between them as much of the diseased tissue as is possible.

As to whether the internal electrode is to be attached to the positive or negative pole will depend upon the degree of irritation of the parts and whether the exudation is of a recent or of a chronic nature. A good rule to follow is to use positive galvanism in the vagina for its inter-polar action as long as there is any active inflammation, or as long as the vaginal roof is sensitive to ordinary pressure. When the condition is chronic, or when the roof is sensitive only to deep and sudden pressure, negative galvanism is indicated. In other words, after pain and congestion are relieved the negative pole is indicated to soften the mass and promote absorption.

A speculum may or may not be used, but when employing a vaginal electrode the speculum must be removed before the current is turned on. If the deposit is localized, the vaginal electrode should be placed directly against it; but if it is not localized, it is better to place the electrode directly against the cervix, so that the current may traverse the whole structure of the uterus. The current should be gradually turned on, employing every precaution to prevent the slightest break

or shock; beginning with 20 or 25 ma., the strength of the current may be increased at each sitting, as tolerance is established, until an intensity of 150 or even higher is reached. The high intensities, when reached, will produce no more discomfort or inconveniences to the patient than the small dose did at the beginning. As a rule, however, an intensity of from 75 to 125 ma. will be the dose most frequently required. The sitting should last from five to eight minutes, when the current should be reduced to zero and the instrument removed. The treatment should be given every second or third day in the beginning and then the intervals lengthened, as improvement proceeds, to once a week or once in ten days.

If after a treatment any pain or distress follows the galvanic application, bipolar faradization of the vagina with the secondary current should be employed for five or six minutes; the strength of the current governed by the feelings of the patient. It should be borne in mind that recent exudations will ordinarily yield readily to positive galvanism; but when the exudation is chronic and the positive pole fails to cause its disappearance, the negative pole will hasten the process of absorption and soften and relax the adhesions.

The length of time required to effect a cure in these cases will depend upon whether the cases are recent or of long standing. If the cases are recent, one or two months is sufficient to bring about a cure; if of long standing six months or even a year are consumed in bringing this about. But this is nothing when we recall that months and years pass under simple medical treatment without any result whatever; while surgery, which jeopardizes life, actually requires from one to two years after operation to effect a cure in not a few cases. In electricity we have a remedy which is absolutely without a particle of risk, which does in six months or a year what medicine fails to do, and what surgery can only do in twice the time with greatly added suffering and dangers. This method is not painful; can be readily applied in our

offices; allows the patient to go about her business afterward, subject, of course, to the usual limitations of caution; does not confine her one instant to her bed; requires no special preparation, and offers the best hopes of recovery. The great obstacle in the treatment of these cases by means of electricity is that as soon as the pain is relieved the patient believes herself cured and consequently neglects her treatment, where, in fact, it is only the symptomatic sign that has been removed, the pathological condition still existing.

In case that the above method of applying the current fails to give the required relief, vaginal galvano-puncture may have to be resorted to. In this method the abdominal electrode remains in the same position as above given, and to the other pole is attached a very fine needle, not larger than an ordinary exploring needle, and the depth of the puncture should be only just sufficient to enter the mass. The positive puncture is to be employed; but in case that its action fails to give relief, the negative galvano-puncture must be resorted to.

Goelet gives the following method of applying galvano-puncture: "The vagina is first rendered aseptic, then the index finger of the right hand locates the tumor in the vagina at its most prominent point, selecting preferably the lateral fornix of the vagina and taking care to avoid any pulsating vessels; then the gutta-percha sheath or tube used for insulating the shaft of the needle is passed along the finger as a guide, pressed against the mass and held in position by the free fingers and thumb of the right hand. The needle, which has been previously arranged so as to penetrate only the desired depth, is passed through this sheath until it touches the surface of the vagina, when with firm pressure it is made to enter the mass at the point selected. Waiting until the temporary irritation of this puncture has subsided the current is turned on very slowly until the maximum is reached; it is held there for a space of three minutes and is gradually turned off, when the needle is withdrawn. The vagina is

again douched with an antiseptic solution and a tampon of iodoform, creolin or aristol gauze is placed against the womb in the vagina."

The treatments are to be repeated about every tenth day; the strength of the current varying from 20 to 60 ma. When employing the negative puncture a stronger current can be given than when the puncture is positive. No anæsthetics are necessary, as there is very little pain attending the operation. The patient should remain quiet for several hours after the operation. As regards the method of the treatment by puncture Dr. W. H. King says: Never resort to it for the purpose of hurrying up absorption until the less heroic methods have failed. Never attempt it unless the case is of very long duration, and all sensitiveness has disappeared, and never attempt it unless a deposit is located posterior to the uterus and so low down that it is adherent to the posterior vaginal cul-de-sac.

ENDOMETRITIS AND METRITIS.

These terms signify inflammation of the lining and of the structures of the womb.

In electricity we possess an energy which is capable of curing these affections, causing at the same time absorption of the hypertrophied tissues and tumefactions of the uterus itself, as well as the other pelvic viscera; causing also the uterus to contract and assume its normal weight and mobility, and sometimes position, and while this is going on the sharp pains in the pelvis, the soreness, feeling of weight, leucorrhœa, and the much dreaded diseased ovaries, gradually vanish, thus relieving the patient, and that, too, without putting her life in jeopardy or mutilating her body.

Leucorrhœa is probably the most frequent symptom complained of by the average patient affected with these troubles, and it is present, to a greater or less extent, in its greater majority of cases. Electricity applied in the manner de-

scribed below will invariably check the leucorrhœa and cure the underlying cause—inflammation.

This method has the advantage not only of accomplishing what the curette and chemical applications do, but also it exerts a local stimulating effect upon the trophic nerves, causing renewed activity of the cells, and, by improving the circulation, relieves the congestion and stasis so often present in these cases. As the value of galvanic intra-uterine applications in the treatment of endometritis and metritis is more generally recognized, their more extended use must render less and less desirable the use of pessaries, curettage, and trachelorrhaphy.

There is probably no method or means that has ever been employed that has proven more effective than the intra-uterine application of the galvanic current in this troublesome and obstinate affection—inflammation of the lining of the cervical canal and womb. The beneficial results obtained from electricity employed in this manner will be a grateful surprise to any who will try it, for it is far superior to the older methods of iodine, carbolic acid, etc.

The treatment of endometritis and metritis is practically the same, for in metritis there is always endometritis, and the treatment for endometritis cures metritis where they coexist.

In the acute stage the galvanic current is prohibited. The faradic current (the secondary only) may be employed in the form of bipolar vaginal faradization to relieve the pain. The fine coil faradic treatment is particularly indicated when the period of relief from pain continues for some time and is prolonged after each application, but not when the period is short and not progressive with the continuance of the treatment.

In the subacute form of endometritis (termed catarrhal endometritis) the judicious use of the galvanic current will check the disease before it assumes the chronic form. Place a large electrode on the abdomen, connected with the negative pole, and apply the positive electrode to the cervical

canal and endometrium, using a current of from 20 to 30 ma., and repeated every second or third day. In order to keep the cervical canal open and patulous, for free drainage, negative applications will have to be made occasionally to the cervical canal, employing a current strength of from 10 to 20 ma.

In the electrical treatment of chronic endometritis and chronic metritis, a cure must aim at the complete destruction of the lining membrane of the uterus, similar to that produced by the application of chemical caustics, without the liability of cicatrization of the latter. This is accomplished with the galvanic current, by applying the active pole (platinum or carbon electrode) directly to the mucous surface; the indifferent pole, a large dispersing electrode, being placed on the abdomen. Either the positive or negative pole may be indicated for the intra-uterine electrode. As a general rule the positive electrode is employed when a soft, friable condition of the uterus exists, with a tendency to hemorrhage, or when there is profuse leucorrhœal discharge; also in the ulcerated and granular forms of endometritis. Where the cervix is stenosed and indurated, or where there are fibrous formations, the negative pole will have to be employed to soften the tissues of the cervix before the positive electrode can be used; also where the canal is filled with thick, tenacious mucus the negative pole will have to be employed before the positive to dissolve and remove the secretions. It would be useless to attempt to cauterize with the positive pole without first removing the secretions from the canal, for the action of the positive pole would cause them to become coagulated, and thereby afford protection for the diseased surface underneath. The choice of the pole is governed also to some extent by the quantity of the flow; if menstruation is excessive, the positive pole is introduced into the uterus; if diminished in amount, the negative is indicated. When the negative is the active pole it is better to use a platinum electrode, for then the reversal of the current will be unnecessary. The strength of the current to be employed will vary. In the be-

ginning of the treatment it is usually better to begin with about 50 ma., and later to increase the strength to 100, 150, or 200 ma. if necessary, always keeping in mind the susceptibility of different patients to the effects of electricity. In the greater majority of cases, however, it will not be necessary to exceed 60 to 75 ma.

With the indicated sound in position, and the indifferent electrode (a large one) placed over the abdomen, the current is gradually increased up to the intensity desired, or to that point which the patient can conveniently bear, and allowed to pass for fifteen minutes, and then gradually reduced to zero. If it is the positive pole that is intra-uterine, reverse the polarity and allow a current of 8 to 10 ma. to pass for five or six minutes, so as to get the relaxing effect of the negative current; otherwise it would often be a difficult thing to remove the electrode, on account of its being glued firmly to the endometrium (a natural sequence of positive cauterization); if the negative is employed as the active pole this procedure will not be required. Having reduced the current to zero, remove the electrode by a slight rotary motion, care being taken to use no force. As the cervix is more sensitive than the fundus, it is best to reduce the current about one-half when treating the cervix. After the treatment it will be better for the patient to lie down for thirty minutes. During the treatment the patient rarely complains of pain unless there is great sensitiveness of the uterus, when the passage of the sound may cause considerable discomfort, and, during the application, pains running down one or the other crural nerve. Should the uterus be intolerant of the presence of the electrode, the galvanic current may be preceded by the faradic.

Care must be taken that these applications are not made too frequently. An application is not to be made until the effect of the previous cauterization has disappeared—that is, until the surface has entirely cleared off. Not more than two treatments should be undertaken during each intermenstrual period.

In some cases, following a treatment, a bloody discharge will continue for days, or even a week or so; consequently there need be no alarm felt when this does occur. There should be no pain or inflammatory action following a treatment.

As a general rule, the platinum sound is used; but where the uterine cavity is enlarged, or where there is profuse leucorrhœa, the carbon electrode is preferable, for it comes more directly in contact with the whole mucous surface than the platinum sound.

In treating a case of endometritis it is very important to have the mouth of the uterus thoroughly dilated so as to allow a free drainage of the uterus and tubes, as the latter will drain if the uterus is not clogged up with secretions, after several intra-uterine treatments.

In metritis with fixation of the uterus from shortening of the ligaments or from adhesions due to pelvic peritonitis electricity will often prove of great service in causing an absorption of this inflammatory product, thereby relieving the uterus and allowing it to assume its normal position.

Massey says that should the endometritis be complicated by a salpingitis or other peri-uterine inflammation, as indicated by a fixation of the uterus, all intra-uterine explorations or treatment should be postponed as unsafe, and recourse be had to vaginal application of from 50 to 100 ma., negative, which most quickly restores the uterus to a movable condition.

The above method of treating endometritis and metritis is termed Apostoli's. Apostoli makes use of the platinum, gold or other non-oxidizable metal for the positive electrode, which is thus enabled to exert its full electrolytic and electro-caustic power on the tissues with which it comes in contact. A modification of Apostoli's method is that known as Gautier's. He employs copper instead of platinum or carbon for the active electrode. A copper sound as large as will pass through the cervix is introduced to the fundus and held

there steadily during the treatment. The electrodes are made of ninety-seven per cent. pure copper, and are insulated so as to protect the external os. If it is not desired to affect the cervix, a coating of shellac dissolved in alcohol will limit the action of the electrode to the portion remaining bare. When copper is employed as an electrode, with the positive pole in contact with the tissues, an astringent salt, the oxychloride of copper, is set free. This has been designated cupric electrolysis. In this form of application the oxygen, chlorine and acids evolved from the tissues in proximity to the positive pole expend their action upon the metal electrode instead of upon the tissues, as is the case when a non-attackable electrode is employed. The result is the formation of salts peculiar to this metal.

The advantage of the method when copper is used is that cauterization is avoided, and a decidedly astringent salt is liberated. Its action upon the tissues is not limited to the surface, as is the case when astringents are employed in the usual manner, but extends to a very considerable distance beneath the surface as well. This form of application is of special value in uterine catarrh and granular degeneration of the cervix uteri—in fact, it has no equal in these conditions. As to the employment of a platinum or copper sound Gautier says: "A clinical comparison, which everyone can make, consists in treating an endometritis, either simple, purulent, or symptomatic, of peripheral lesions, first with a platinum electrode, then with one of copper, or vice versa. The verdict is pronounced. The woman will experience real relief from the use of the soluble (copper) electrode; it will be quite rapid, and, above all, it will be lasting. If we try to find out from the patient which electrode she prefers, she will never make a mistake in her choice; she will always name the application made with the copper."

In some instances a zinc electrode is preferred. When zinc is employed an oxychloride of zinc results from the action. This salt exerts a very marked caustic action. The

chloride of zinc cauterization, employed in this manner, has been found useful in certain forms of endometritis; for example, when associated with a condition of sclerosis of the uterine tissue, owing to the peculiar softening effect of its action. In cases of granular and cystic degeneration of the cervix, a very rapid cure can be effected by this method of application.

Another important application of zinc electrolysis is in the destruction of fibroid, keloid, and cancerous growths.

When either copper or zinc are employed the current is not used as strong as when platinum or carbon are employed; the current strength ranging from 30 to 60 ma. Otherwise the directions given above are applicable where these electrodes are used.

HEMORRHAGIC ENDOMETRITIS.

The positive pole of the galvanic is always indicated, though at times it is advisable to use the negative first for the purpose of dissolving thickened secretions. Massey gives the following directions: "Select the largest one capable of being inserted, pass it gently to the fundus, and then turn on a current of 40 to 100 ma. The electrode is held in this position from one to three minutes; the current is then lessened, and with the fingers in the vagina, locating a notch, the electrode is withdrawn until another notch is touched; then the current is again turned on to the same strength and for the same duration. This sectional cauterization is repeated until the bulb again impinges on the internal os, the whole of the endometrium being thus brought into contact with a concentrated polar section." It is not always necessary, however, to give such thorough treatment. This form of treatment will only be necessary in the more severe cases. In the milder cases the platinum electrode will answer all purposes.

OVARITIS AND SALPINGITIS.

There is probably no class of diseases which gives the general practitioner so much anxiety, and which is more often unsuccessfully treated, than inflammation of the pelvic organs. Especially is this the case of ovaritis and salpingitis. The endometrium can be successfully curetted and treated antiseptically, applications being made directly to the diseased parts. Not so with the tubes and ovaries. They are out of reach of local applications, and we must, therefore, look for other means to reach the diseased parts. We find no agent so efficient in this emergency as electricity.

In the acute stages much can be accomplished by the judicious use of electricity. Only the faradic current is permissible in this stage, and the best results are obtained from the secondary coil. The current should be applied by means of a bipolar vaginal electrode. The current must be turned on very gradually; starting from an almost imperceptible point, the strength of the current should be increased gradually and with reference to the patient's tolerance. The application should be prolonged from fifteen to thirty minutes, or until absolute sedation and relief of pain are secured, and they should be repeated every day at first, but later every alternate or every third day. This treatment must be persisted in until permanent relief of the pain is obtained and the sensitiveness to digital pressure has been overcome. In the subacute stage, in addition to the vaginal bipolar faradization, the galvanic current may be used on alternate days. It also, as well as the secondary faradic, will set the absorbents to work in the cure of the disease. The positive pole, on account of its sedative qualities, should be employed as the active internal electrode. For the internal electrode, use the carbon ball, clay-covered electrode. This should be introduced into the vagina up to the vault, as near to the affected ovary as possible. The indifferent electrode is placed over

the abdomen or over the sacrum, preferably the latter position, if the ovary is displaced downward or backward, for in that case the current passes directly through the affected organ. The strength of the current will vary according to the sensations of the patient, varying from 15 to 30 ma; the duration of the application varying from ten to fifteen minutes, and followed every time by vaginal bipolar faradization with fine coil for six or eight minutes. In the chronic stage the treatment is that which has been given for "Pelvic Exudations," which compare.

In cystic degeneration of the ovaries Goelet advises placing the positive pole in the vagina as near the cyst as possible, the external electrode placed over the lumbar or sacral region, commencing with about 30 to 40 ma., every second or third day, gradually increasing to 50 or 60 ma., and lengthening the interval as the strength of the current is increased. From 80 to 100 ma. can, after a while, be employed once a week. He says that milder applications will not be effective. Bipolar faradization may be employed during the interval between the galvanic applications. In some instances unipolar applications of the faradic current (one pole in the vagina and the other over the lumbar region) will give better results than the bipolar method.

Salpingitis or inflammation of the tubes, due chiefly to an extension of an endometritis along the lining membrane of the tubes which is continuous with that of the uterus, will often be entirely relieved by curing uterine inflammation, correcting a mal-position which causes a dragging upon the tubes and ligaments and establishing a healthy cervix and free cervical canal.

DISPLACEMENTS OF THE UTERUS.

Versions and flexions of the uterus are due to a great extent to inflammations of the parenchyma of the womb which lead to displacement. They also result from pelvic peritonitis, diseases of the appendages, and sub-involution. Consequently

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much that has been said in regard to the treatment of these various conditions will apply to the treatment of uterine deviations, as they are mainly the causative factors of these conditions. In uterine displacements of recent origin, from accident, etc., the tonic effect of bipolar faradization will prove beneficial in strengthening the uterine supports. In such cases only the long fine wire should be used, until all inflammatory conditions have subsided, then the short coarse wire will be found to be more beneficial.

In chronic cases of uterine versions and flexions the faradic current coarse wire coil will be the form to depend upon chiefly. In anteversion and retroversion employ bipolar vaginal and bipolar uterine faradization ; while for the flexions it is better to insert one electrode in the uterus and place the other over the abdomen in case of retroflexion, or over the lumbar region in case of anteflexion. The application should not be made until three days after the end of the menstrual period ; the seance should last for ten minutes, and be repeated twice a week. The strength of the current should be sufficient to cause slight uterine contractions perceptible to the hand holding the uterine electrode. If the uterus is bound down by adhesions, they should first be broken up and absorbed by the employment of the galvanic current, the negative electrode within the uterus and the positive over the abdomen, using a current strength of from 50 to 100 ma., as described under " Pelvic Exudations."

SUBINVOLUTION.

This is a condition in which the uterus is found occupying a lower position in the pelvis than normal, sometimes coming quite down to the mouth of the vulva, and at the same time it is congested, enlarged, and relaxed. It follows quite frequently after labor and after abortions and miscarriages.

In electricity we have an energy which is capable of causing the uterus to contract and assume its normal weight and position. The primary faradic current is the form of electricity that

will prove the most serviceable in this affection; in fact, there is not another remedy its equal. In the beginning it should be employed by a bipolar electrode to the vagina, and later by means of the intra-uterine bipolar electrode to the cavity of the uterus. The treatments may be repeated every other or every third day, according to the severity of the case.

In subinvolution with hemorrhage the swelling faradic current of low tension and slow interruptions, intra-utero-abdominal method. The ordinary platinum intra-uterine electrode in the uterus, and a large flat electrode over the abdomen. The current is gradually increased up to the point of tolerance and continued for about ten minutes; treatments twice a week.

Where the subinvolution is due to septic endometritis, the results of shreds of retained decidua or a laceration, the galvanic current is indicated, the positive pole in the uterus and the negative on the abdomen. An enlarged and heavy uterus, if caused by engorgement, requires positive galvanism; if by increase of the fibrous elements, negative galvanism.

MAL-DEVELOPMENT OF UTERUS AND APPENDAGES.

In mal-development the unstriped muscular fibre is usually so scanty that the uterus is deficient in size. Electricity, properly applied, is the best remedy to correct mal-development of the uterus and appendages. Faradization will develop the muscular tissues and stimulate the involuntary fibers of the blood vessels. The galvanic current will produce a determination of blood to the parts, thereby affording pabulum for development of tissue.

Faradization followed by the galvanic current is the most reliable means we have of developing the uterus. When the faradic current is employed, place one electrode over the abdomen and the other in the uterus if possible; but if an electrode cannot be entered into the uterus, use the vaginal ball electrode and pass it up to the uterus. The current

should be as strong as can be borne and the application for ten minutes, repeated once or twice a week, using the coarse coil wire. When the galvanic current is employed the same method of application is to be employed as for the faradic current, the internal electrode being connected with the negative pole.

UTERINE HEMORRHAGE.

The control of uterine hemorrhage by electricity is one of the things in medicine that can be almost, if not quite, assured.

In the treatment of hemorrhage from the womb employ the galvanic current (an exception to this is in *post-partum* hemorrhage, when the faradic current will prove the most serviceable), the positive pole in the uterus and the negative electrode (a large clay electrode) on the abdomen. If the bleeding is not very profuse, and the uterine canal is narrow, an ordinary platinum sound will be sufficient to make the application with; but if the bleeding is excessive, and the uterine cavity is large, to get the hemostatic action of the positive pole the sound has to come in direct contact with the lining of the womb. In such a case a carbon electrode will have to be employed, and the cavity of the uterus cauterized in sections, as described under "Hemorrhagic Endometritis." The carbon electrode will be called for especially in those severe hemorrhages which so often occur in connection with fibroid tumors, where, if not checked promptly, they may jeopardize the life of the patient. The strength of the current will vary according to the severity of the case; the milder cases requiring from 30 to 60 ma., while those cases requiring the use of the carbon electrode may require from 75 to 150 ma. Even in cancer of the uterus positive intra-uterine galvanism will control the hemorrhage and retard the growth, and in this way prolong the patient's life.

Post-partum hemorrhage and all hemorrhages from the uterus due to relaxation of muscular fibers are best treated

by the faradic current; either one pole in the uterus and the other to abdomen, or both poles within the uterus by means of the bipolar intra-uterine electrode. In fact, no measure or remedy will prove as efficient in controlling *post-partum* hemorrhages as bipolar faradization. It causes an immediate strong uterine contraction, and is a sure and safe remedy, even in hemorrhages of the most severe type. Sanguineous discharges continuing beyond the normal periods of their appearance, or recurring during the first week after parturition, may be controlled by one to three of these applications. Either the bipolar or unipolar method may be used.

In uterine hemorrhage due to sub-involution resulting from abortion or a protracted convalesence after a confinement an application of the primary faradic current will check the hemorrhage, and by producing powerful contractions of the muscular walls the blood supply will be reduced, fatty degeneration will result, the excessive muscular element will be absorbed, and the uterus reduced to its normal size, with a healthy membrane.

In those cases of uterine hemorrhage occurring in women, about the end of the climacteric, when sexual activity is on the decline or has entirely ceased, in consequence of inactivity of the liver and constipation, associated with a degree of nervous exhaustion, general faradization with its powerful constitutional tonic effects will prove of valuable service.

EXTRA-UTERINE PREGNANCY.

Electricity has proven a valuable agent in checking and destroying this growth. Either the secondary faradic or the galvanic current may be employed; but, as a rule, the interrupted galvanic current will be preferable. Place one electrode on the abdomen directly over the tumor and the other either in the vagina or rectum, according as to which will allow the electrode to be placed nearer to the growth. The strength of the current must be as strong as can be borne by the patient, and continued for about ten minutes; the treat-

ments must be given every day or every other day as long as there are no unfavorable symptoms arising, or until the death of the fœtus is assured.

STERILITY.

Sterility may be due to a stenosis of the uterine canal, to endometritis, or to non-development of the uterus; it is also often dependent upon a condition of the uterus characterized by membraneous menstruation. There are other causes which do not come under this heading, such as sterility of the male, and that form of sterility in the female known as *relative*, where the female does not conceive with one individual but does with another.

Sterility due to stenosis of the uterine canal will, as a rule, be overcome by dilating the canal and giving free drainage to the uterine cavity. Dilatation may be performed (*a*) by means of a steel dilator without the employment of electricity; (*b*) by means of the negative uterine electrode. There are several reasons why dilatation by means of electricity is preferable to rapid dilatation by means of the sounds: (1) On account of its simplicity and safety; (2) it does not require the employment of an anæsthetic; (3) it is devoid of danger, unless imprudently used; (4) it leaves the cervical canal patulous, consequently allowing a better condition for drainage; (5) finally, in all cases of stenosis of the cervical canal there is more or less of a catarrhal condition of the lining of the womb, and by the employment of the negative electrode to overcome the stenosis this catarrhal condition is benefited. In sterility due to catarrhal conditions of the uterus the results from the use of electricity are infinitely better than those obtained by means of dilatation with the steel sounds, and with far less probability of tubal complications, or of extra-uterine pregnancy.

In employing electricity place the positive electrode over the lumbar or abdominal regions, then select the smallest uterine electrode, and, after turning on the current (a very

mild one), the electrode is made to traverse the cervical canal slowly; it will be arrested at the contracted portion until the electrolytic action permits it to pass without the use of force. When it passes the point of stenosis, introduce it into the fundus of the uterus, and let it remain there three or four minutes; then slowly withdraw it, but before it leaves the canal turn off the current. The current strength will vary; during the time the electrode is passing along the uterine canal, from 10 to 15 ma., but when it is passed to the fundus of the uterus, in order to affect the endometrium favorably, increase the current from 25 to 50 ma. The treatment should be given often enough to keep the cervical canal open and in a patulous condition; usually one treatment a week, until six or eight have been taken, then once or twice a month for a few months, unless the patient should become pregnant.

The use of the negative pole not only secures the drainage of the uterine cavity and fallopian tubes, but also destroys the diseased mucous membrane lining the uterus; or, in other words, cures the endometritis which so frequently coexists with sterility. Sterility is often due to endometritis and the consequent alterations in the secretions from the uterine and cervical mucous membrane, so that it has become acid or otherwise fatal to the spermatozoa, rather than to stenosis of the cervical canal. In such cases, by curing the endometritis the secretions from the uterine and cervical mucous membranes will become normal, and the woman, all other conditions being favorable, will conceive.

Sterility due to want of development of the uterus can be cured, in many cases, by bipolar vaginal and intra-uterine faradization with the primary current.

In many instances where the menstrual flow has been growing less in quantity and irregular in its appearance, by the use of the galvanic current (negative pole intra-uterine) the flow has increased in quantity, its appearance has become more regular and eventually the woman conceiving and bearing a child.

UTERINE FIBROIDS.

As to location, fibroid tumors of the uterus are divided into three classes: (1) When the tumor is located in and grows within the wall it is *interstitial* or *intra-mural*; (2) when it is forced out of the uterine wall into the peritoneal cavity it is *subperitoneal*; (3) and when it projects into the uterine cavity it is *submucous*.

As to structure these tumors are divided into two classes: (*a*) Soft or myomatous growths, when muscular tissue predominates, and (*b*) hard or fibromatous growths when they are composed of connective tissue, and are hard and fibrous in structure.

The interstitial variety is the one most amenable to electrical treatment. Involving, as it does, the walls of the uterus the current can be brought in direct contact with it. The subperitoneal is, as a rule, attached to the uterus by a small pedicle, and unless it is in a position that it can be reached by electro-puncture is not amenable to electric treatment. The submucous variety is also attached by a pedicle and can best be treated by surgical measures—dilatation of the cervical canal and enucleation, electricity being indicated before their removal only when they are not sufficiently separated from the uterine wall to admit of removal.

It is not in every case of fibromata that electricity will be called for. Fibroids complicated with acute uterine or peri-uterine lesions, or with chronic suppurating peri-uterine lesions, cystic or fibro-cystic tumors of the ovaries or tubes, soft fibroids or fibroids complicated with ascites, are not, as a rule, amenable to electricity.

It must be remembered, however, that a simple chronic peri-uterine lesion does not contra-indicate the treatment as a rule; it contra-indicates high intensities only. It is often the case that intensities of from 30 to 60 ma. can be given, and then not only the fibroid receives benefit, but also the co-existing peri-uterine inflammation.

Electrical treatment should never be employed if there is reason to suspect that the tumor has already begun to undergo malignant metamorphosis, for under such circumstances electricity will certainly aggravate the condition.

If these tumors continue to increase in size it is a sign that electricity in that case will do no good. The probabilities are that it is not a true fibroid but a fibro-cystic tumor, for a growth of a cystic nature will be increased by the application of galvanism.

In those cases, however, in which electricity is indicated—and this includes the greater number, about 85 per cent—it far surpasses any other known method of treatment. True, electricity will not cure or even relieve all cases of fibroid tumors of the uterus, but in the great majority of cases some benefit may be expected.

Even in those cases where surgical measures have to be eventually resorted to, the proper use of electricity in these cases does not complicate a subsequent operation for the removal of the tumor, but, on the contrary, facilitates the removal of adhesions and produces a marked improvement in the general condition of the patient. In very large, hard tumors, where much retrogression cannot be expected, if the general health has become deteriorated, electricity serves a useful purpose in building up the general health of the patient to a point where an operation for the removal of the tumor will be tolerated. Statistics from a large number treated by electricity show that 29 per cent. are relieved, 27 per cent. symptomatically cured, 7 per cent. are not benefited in any way, and 37 per cent. are absolute cures. This is a much better showing than by any other method or combination of methods.

In some cases a very marked reduction in size of the tumor will occur, while in others no appreciable diminution can be noticed ; the pain and distress are, as a rule, relieved ; also the hemorrhage is checked. These symptoms can sometimes be so completely relieved as to lead to the belief, as far as the

patient is concerned, that the tumor has entirely disappeared. In the great majority of cases, however, it is simply a symptomatic cure. The tumor is still there, but reduced in size, and so far as pressure upon surrounding parts is concerned, or any hemorrhagic tendency, is entirely harmless.

Electricity is of special value in intra-mural growths, and in that class of tumors the pressure symptoms are invariably relieved, the general health improved, and in hemorrhagic cases there is an arrest of the hemorrhage. In recent growths, and in myomata, retrogression is the rule.

In employing electricity (galvanism) in the treatment of fibroid tumors of the uterus, there are two methods of applying it: (1) Introducing one electrode into the uterine canal, and this is the method that should be depended upon chiefly; this method is termed galvano-cauterization; (2) inserting a needle, which is attached to one pole, directly into the substance of the tumor; this method should only be resorted to when the other has been given a fair trial and failed; this method is known as the galvano-puncture.

When employing the first method, the choice of poles, that is, whether the positive or the negative is to be attached to the internal electrode, will depend upon certain pathological conditions. The positive pole is indicated in fibroids accompanied by hemorrhage and pain, and in those complicated with simple or specific endometritis, or a chronic non-suppurating peri-uterine affection; the negative, when the fibroids are large, hard and subperitoneal, and when there is not much hemorrhage, for if anything it increases the tendency to bleeding. Even in those cases in which there is no hemorrhage it is usually better to apply the positive pole for the first treatment or two. After all hemorrhage has ceased, then substitute the negative pole for the positive, on account of its power of producing absorption.

In many cases of fibroids, hemorrhage will be found to be very severe. In the most of those cases, extensive vegetations of the endometrium are found to be present. These

should be removed before electrical treatment is begun by means of the curette. Curettement is likewise indicated when bleeding persists under appropriate electrical treatment, and when a hemorrhage occurs after it has been controlled by the treatment. If there is much pain, a few preliminary treatments may be given for its relief before active treatment is instituted: Pass the clay-covered carbon ball, connected with the positive pole, into the vagina directly against the tumor, the negative electrode being placed on the abdomen; use a current strength of from 30 to 50 ma., for ten minutes, every day or every other day.

In regard to the indifferent or external electrode, care will have to be observed in selecting a proper one, and in applying it; for when high intensities of current are used, great pain is liable to be produced if the electrode is not properly applied. Either the large abdominal clay pad electrode, as advocated by Apostoli or Goelet, or some one of the abdominal electrodes that are made by American manufacturers may be employed. The surface of the abdomen must be examined to find any abrasions or pimples. If any, cover them with collodion or with rubber plaster, or on account of the lessened resistance at those points intense pain will ensue.

The patient is to be placed on the operating chair or table, on her back, the hips drawn well forward, and extending beyond the edge; the clothing having been loosened and the abdomen made bare and the abdominal electrode having been placed in position, the patient locks her hands across it and during the application presses gently down on it (a bag of sand will prove of good service for this purpose); the platinum sound having been well sterilized is passed into the uterus and gently pushed to the fundus of the uterus. Then gradually turn on the current to the full limit that the patient can bear, all the time watching the patient's face, and at the first sign of distress cease to increase the current, and if needful reduce it slightly. Then after a few moments begin increasing the current strength and continue gradually

until the desired intensity is obtained. At the end of the treatment the current must be gradually reduced, for with these high intensities any interruption of the current would give a dangerous shock to the patient. The duration of the application will vary from eight to fifteen minutes, according to the intensity of the current used and the patient's tolerance. The strength of the current will vary from 50 to 200 ma. After each treatment the patient becomes more tolerant to the higher intensities; consequently always begin with the lower intensities and gradually work up to the higher, beginning with 20 or 25 ma. The interval between sittings should be long enough for all pain or discharge produced by the previous treatment to have ceased. The mistake is often made of giving the treatment too frequently. A too frequent application will often increase the hemorrhage instead of lessening it. Treatments should not, as a rule, be oftener than every ten days.

Following the treatment. faradism from the coil of fine wire, for eight to ten minutes, is of great service in relieving the pain caused by high intensities of galvanism. After each treatment the patient should lie down for a half hour before leaving the office, and should keep moderately quiet for a day or so. During the intervals of treatment she should take an antiseptic vaginal douche morning and evening.

It quite frequently happens that after one of these applications the patient is subjected to a severe uterine colic; she should be forewarned of this so as to prevent any unnecessary alarm.

The number of seances will vary in different cases, in some cases five or six being sufficient, while many require thirty or forty or even more.

In some instances, where the electrode cannot be inserted into the uterus, good results may be obtained by using the vaginal clay-covered ball electrode, connected with the negative electrode, passed up into the vagina and pressed against the tumor, the positive pole being attached to the large ab-

dominal electrode, and the method conducted as laid down under "Pelvic Exudations."

As a rule, however, when it is impossible to introduce the electrode into the uterine cavity, the galvano-puncture will have to be resorted to. There are two methods of puncturing a fibroid tumor: (*a*) Internal; (*b*) external. When the internal method is employed, the puncture is made through the vagina, while for the external method, the most prominent part of the tumor is selected as the point to insert the needle. The external method is to be employed only when other methods can not be employed. It is especially called for in very large tumors and in floating fibroids. When this method is employed the indifferent electrode is placed beneath the back. Either in the internal or external method, the needle should be insulated to within a half inch or inch of its tip, according to the size of the tumor to be operated upon, and should be well inserted into the substance of the tumor; care being observed, however, not to insert it too far or the current will escape from its point into the healthy tissues and its effect on the tumor lost; no pain must be felt by the patient at the point of the needle, as that would be an indication that the point was too near the edge of the tumor; in case pain is felt the treatment must be stopped. The current strength can be run up higher in these methods than when applied by an electrode—varying from 100 to 250 ma. The duration of the application will vary from five to ten minutes, and should be repeated once a week. The negative puncture is preferable on account of its absorbent power being greater and the drainage better. Strict antisepsis is of the utmost importance, and if the operation is so conducted the danger to the patient is reduced to a minimum.

MENSTRUAL DERANGEMENTS.

Of the many ailments that women have to bear none causes so much complaint as the derangement of the menstrual functions: Every twenty-eight days (beginning at about the

twelfth or fourteenth year, and continuing about thirty years) a woman should have what are termed the "monthlies," "periods," or "flow." This varies in amount in different women even in health, and lasts usually from three to five days.

The fact has long been established that there is a close relationship between woman's menstrual function and her diseases; especially so with her pelvic pathology. Also, it is well known that those women are most healthy who have the periodical discharge most regularly; and, on the contrary, those who have bad health either have it excessively, sparingly, irregularly, or want it altogether.

The function of menstruation, being a natural one, should be devoid of all pain and suffering, but unfortunately such is rather the exception than the rule. So commonly is it accompanied by annoying disorders, such as headache, or pain in the small of the back and groins, that women in speaking of menstruation usually refer to it as "being unwell." In fact, few women are free from the tormenting headaches, backaches, ovarian neuralgias, gastric and vesical irritations during this period.

It is in the treatment of the various diseases peculiar to women that electricity has won its greatest laurels, and it has been employed in the treatment of menstrual derangements since its first introduction into medicine, more than a hundred years ago. It is a powerful remedy in the various functional disturbances of menstruation and has assumed such an important position that the study of its nature and its action in these affections is absolutely essential to an earnest physician or surgeon who has a regard for the best interests of his patient.

When we remember that three-fourths of womankind suffer from some wrong of menstruation and that no single measure has ever yielded one-half the benefits that has been obtained from the judicious use of electricity, we can appreciate the fact that it is the most valuable acquisition in the treatment of diseases of women that has ever been brought

forth; and that in many instances recourse need no longer be had, as is too often the case, to harmful drugs or to curettage.

The three chief disorders relating to the menstrual functions are: (1), Amenorrhœa; (2), dysmenorrhœa; (3), menorrhagia; also vicarious menstruation.

AMENORRHŒA.

Amenorrhœa signifies an absence of the monthly flow. There are two distinct varieties of amenorrhœa: (1), Where menstruation is absent and has never appeared—termed *retention.* (2), Where the flow, after having been established, ceases to appear at its regular intervals—termed *suppressed* menstruation. Scanty or irregular menstruation is usually classed as a variety of amenorrhœa; but, strictly speaking, it is not a true amenorrhœa.

Non-appearance of the menses may be due to a non-development of the uterus and ovaries, or, in rare instances, an absence of these organs; general anæmia; chlorosis; exhaustive constitutional diseases, such as tuberculosis, Bright's disease, etc.; fright; grief; mental overwork; indolence; luxury; want of fresh air and exercise. Costiveness sometimes occasions it. Girls who have been raped or who have "gone astray" may become so anxious and worried about their condition as to cause them to pass over their regular time several days or even weeks; the same holds good in recently married women; also "taking cold" during the menstrual period may cause a suppression of the flow at the time when the next period should make its appearance, and possibly for several periods before it becomes re-established.

Too often electricity is employed to "force" the monthlies in certain cases where such a result cannot but prove harmful; for instance, amenorrhœa occurring in a girl or woman who is suffering from chlorosis, general anæmia, or tuberculosis should be left severely alone, for it is nature's way of conserving her strength.

There are two methods of applying electricity in amenorrhœa: (a) The external method; (b) the internal method.

In the external application of electricity galvanism is the preferable form to use. The spine should be thoroughly galvanized. The direction of the current is of great importance; a descending current, by its reflex and radiating action, affects more profoundly the different organs of the body which receive their nervous impulse through the spinal nerves than an ascending current; it acts by producing a turgescence of the pelvic vessels, and is especially stimulating to the uterus and its appendages. The positive pole should be placed over the nape of the neck, the negative over the lower sacral region, and the current permitted to flow for ten to twelve minutes. The strength of the current, 5 to 10 ma., is to be governed by the feelings of the patient. The treatment should be twice a week, and continued until two or three normal periods have been passed, and once a week for several applications. In some instances a better effect is obtained by passing the negative electrode over the region of the ovaries and the lower part of the abdomen, just over the pubes, thereby including the pelvic organs directly in the circuit, the positive pole remaining on the nape of the neck, the duration of application, strength of current, etc., being the same as above given.

In obstinate cases of amenorrhœa the internal method of applying electricity will have to be resorted to. In fact, it is better to treat all cases of amenorrhœa by this method, as the results are obtained much more quickly than by the external method. In the case of young girls, however, a physician is not justified in applying electricity internally until a faithful trial of the external method has been employed. In the internal method both the galvanic and faradic currents are to be employed. They may both be employed at the same sitting or at alternate sittings.

When the galvanic current is used, place the positive pole over the sacral or cervical regions (preferably the latter) and

connect the negative with the internal or uterine electrode, which should be insulated so as to protect the vaginal parts, and then after careful antisepsis of the vagina and cervical canal introduce this electrode into the fundus of the uterus. The strength of the current should not exceed 5 ma., and the sitting not over five minutes, and repeated once or twice a week. This method of treatment stimulates the uterus and its appendages, causes a flow of blood to those organs, and at the same time leaves the canal of the uterus in a patulous condition, thereby affording a better facility for a free passage of the menstrual flow when it does start. After each sitting the galvanic application should be followed immediately by bipolar faradization of the vagina for five or ten minutes with the secondary current.

When using the faradic current, the best results are attained by applying the current inside of the uterus by means of a bipolar electrode. The strength of the current should be just what the patient can comfortably bear, and the treatments twice a week until a flow is established, and then once a week until four or five treatments have been given. Intra-uterine bipolar faradization may be employed to stimulate the uterus (in that case the primary current), or to allay the pain induced by the use of the galvanic current (in the latter case use the secondary current).

Bipolar intra-uterine, or bipolar vaginal faradization is especially useful in those cases of scanty menstruation and amenorrhœa occurring in women soon after marriage, who, as the menstrual flow diminishes or stops, become stouter and stouter. When there is scanty flow due to uterine catarrh, the bipolar intra-urine electrode should be used to produce local stimulation.

There are many women about the age of thirty who, though fleshy and apparently well-supplied with blood, do not menstruate at all, or but slightly. These women feel uncomfortable and suffer from many nervous symptoms. Anything that will bring on a full return of the menstrual flow

gives them immense relief. This condition can, as a rule, be better overcome by means of the secondary faradic current applied intra-uterine, twice a week, until the periods are re-established, than by any other agent. Not only will the flow be re-established, but the uterus, which before measured less than normal, will soon develop to its full size.

The faradic current may also be given by the unipolar method, that is, one electrode is placed over the cervical or lumbar region, and the other within the cavity of the uterus by means of a uterine electrode, or applied to the os by means of an insulated cup-shaped electrode, or within the vagina by means of a vaginal electrode.

In cases associated with, and more or less dependent on, anæmia or chlorosis or nervous exhaustion, the important thing is not to specially stimulate the uterus, but to change the constitutional condition, which is the cause of the suppressed function. In such cases general faradization or static electricity will be called for. When employing static electricity, seat the patient upon the platform; connect platform with positive pole; ground negative pole, and give treatment in this way for about fifteen minutes. At later sittings mild sparks may be administered to the spine and ovarian region; treatment once or twice a week.

In a great majority of cases of amenorrhœa, especially of young girls, constipation is a troublesome and obstinate complication. In such cases the first line of treatment is to remedy this.

Occasionally cases of entire absence of the uterus or of the ovaries have been met with, and any attempt at relief for such conditions will be useless. But where any or all of them exist in an infantile or rudimentary state relief may be found in stimulating them, thus increasing their growth, and for this purpose the faradic current, the coarse coil wire, will prove the most efficient.

DYSMENORRHŒA.

The term dysmenorrhœa, as the name implies, means a difficult monthly flow, or painful menstruation. Dysmenorrhœa should be applied only to menstruation accompanied by severe pain, not to those cases where the individual complains of other discomfort than a mere sense of fullness about the pelvis, slight pain in the back and loin, and a general feeling of lethargy.

Many women never pass the menstrual period without pains, more or less distressing. When these pains are slight and of short duration the period may be passed without any inconvenience; but in those cases of painful menstruation to which the term dysmenorrhœa has been applied, the patient may suffer from distressing and agonizing pain for hours before relief can be obtained.

The pains are usually located in the region of the womb, and radiate from that point to the small of the back and down the thighs. The pains may make their appearance a few hours before the flow starts, or may not come until a slight "show" has appeared, and usually as soon as the flow comes freely the pains disappear.

Very often, however, the pains begin two or three days before the flow starts, and may extend over the lower portion of the abdomen, at times running down the thighs, with great distress in the back. In many instances the pains are so violent as to resemble those of abortion or labor, compelling the patient to remain in bed for several days, and in rare instances may throw her into spasms. There are, beyond question, many thousands of women who have suffered unnecessarily for years from this painful condition, for this morbid condition is almost invariably amenable to treatment, and should not be neglected, as the repeated attacks of violent pain have a disastrous effect on the general health; while the disorder producing the pain surely increases as time goes

on if left to itself, for pathological states rarely remain stationary for a term of years.

Electricity is one of the most useful of all remedies at our command in the treatment of dysmenorrhœa. The benefits derived from the employment of electricity in the treatment of dysmenorrhœa will be of so marked a character, and the patients so treated will experience such decided relief, that no physician should fail to give them the benefits of its advantages.

Dysmenorrhœa is due to obstruction, inflammation, or neurosis; and as a general rule, is the result of one or more of the following causes: A diseased condition of the lining of the womb; congestion or inflammation of the ovaries or ovarian tubes; a general debility, especially a depreciated condition of the nervous system, thereby setting up a tendency to neuralgia. Quite frequently climatic exposure or mental trouble may act as exciting causes.

According to the usual classifications, there are five varieties of dysmenorrhœa: (1) Neuralgic; (2) inflammatory or congestive; (3) obstructive or mechanical; (4) membranous; and (5) ovarian dysmenorrhœa.

The most commonly severe form of this disease is the neuralgic, and it usually occurs in women of nervous temperament. In neuralgic dysmenorrhœa the results of electrical treatment are frequently most brilliant, and follow after years of ineffectual effort by other means to relieve the periodical seasons of distress. The galvanic, the faradic, and the static will all prove of service, but as a rule the galvanic is the best form of electricity, and will prove more effective in affording permanent relief.

When the galvanic is employed, place a large electrode, connected with the positive pole, on the abdomen; the negative pole may be either the uterine platinum sound or the vaginal ball electrode. The current strength will vary from 30 to 60 ma.; the duration of the application from eight to ten minutes; the treatment repeated twice a week during

the interval between the menstrual periods. It will be well to follow the galvanic treatment with the faradic current from the long fine wire coil, either by attaching it directly to the instruments already in place or by substituting the intra-uterine or intra-vaginal bipolar electrode. The current should be as strong as the patient can bear without producing pain, and continued for five or ten minutes. In some cases it will be better to give the galvanic at one sitting and the faradic at another.

In those cases of neuralgic dysmenorrhœa where the patient is anæmic and suffers from general debility, nothing is so effective for the whole constitution as static electricity. It stimulates and soothes at the same time the whole nervous system, and as a consequence, nutrition is improved. Insulate the patient with the positive pole for ten minutes, and then apply the spray or very mild sparks over the lumbar and ovarian regions for five minutes; treatments repeated twice a week.

Inflammatory dysmenorrhœa is the result of inflammation within the pelvis. The endometrium is, as a rule, either primarily or secondarily in a state of inflammation or congestion. It begins as a dull, aching pain in the uterus, appearing several days before the flow comes on, gradually lessens as the flow becomes fully established, and disappears before menstruation ceases. Sometimes the pain is paroxysmal, simulating that of mechanical dysmenorrhœa, and is due to uterine contractions, which are supposed to occur during normal menstruation, but which are not painful unless there be endometritis or stenosis. The treatment for this form of dysmenorrhœa is the same as that for "Endometritis," which compare.

Obstructive or mechanical dysmenorrhœa depends upon some mechanical impediment to the function of menstruation. The obstruction may be due to flexion of the uterus or to a stenosis. The pain is paroxysmal in character, and when the flow starts the pain eases down and ceases when the

flow becomes fully established. When this form of dysmenorrhœa has lasted for several years, it becomes complicated with the inflammatory variety, and the pains may be so severe in such cases that the patient has to keep her bed for several days.

Where there is flexion, it should be corrected. The faradic current, with slow interruptions, should be used. Use a bipolar intrauterine electrode, so as to concentrate the whole current in the uterus. An elastic or pliable electrode should be used, as by it the uterus can be straightened while the current is flowing. The electrode is to be introduced with care into the uterus beyond the flexion, so that one pole will exert its influence upon the body and one upon the neck, allowing the whole uterus to be in the circuit.

When the dysmenorrhœa is due to a stenosis, the galvanic current must be employed chiefly. The negative pole of the galvanic current, properly employed, is one of the best means of dilating the cervical canal. One of the best electrodes for this purpose is Goelet's dilating negative electrode for the cervix. This electrode consists of five graduated bougie tips, the smallest being the size of the uterine sound. Before beginning the treatment care should be taken to render the vagina and mouth of the womb as aseptic as possible. Then introduce the negative electrode (begin with the smallest one) along the finger as a guide, or a speculum may be employed if so desired,—as a rule, it is better to employ one,—but care must be taken that the electrode does not come in contact with it while current is turned on, or it will cause a severe and painful shock to the patient. This danger can be avoided by having the electrode insulated down to the bougie tip or by using a non-conducting speculum. It is better to use the round celluloid speculum, as it can be perfectly sterilized and will not inconvenience the patient by its weight during the treatment; it being a non-conductor, there will be no straying of the current if the electrode rests upon it. The sound can be applied with greater nicety and less

pain through the speculum than with the finger; also, there is less danger of conveying the germs to the endometrium through the sterilized speculum than with the finger alone in the vagina.

The positive electrode, a large flat one, four by five inches square, may be placed either over the lumbar or abdominal regions. When the current (in strength 8 to 12 ma.) is turned on, the negative electrode should be pressed gently (do not use force) in the direction of the curve of the canal; and after it passes the internal *os* it should be passed to the fundus of the womb and allowed to remain in that position one or two minutes. While the current is still passing, the electrode should be gradually drawn through the stenosed portion of the canal, and then the current shut off. In many instances an application of this kind is followed by severe pain. To prevent this, or relieve it if present, employ bipolar faradization to the vagina with the current from the fine wire coil for five or ten minutes.

Membranous dysmenorrhœa is that variety in which the paroxysm terminates in the expulsion of a membrane from the uterus. The membranous form of dysmenorrhœa may consist of a whole cast of the inside of the uterus, containing its three openings, or the membrane may come away in partial casts, pieces and shreds. This form must not be mistaken for the products of pregnancy. The pain commences with the flow, comes on in paroxysms, and increases in severity until it finally resembles labor pains. After a few hours or days the membrane is shed and the pain ceases to return. This is commonly followed by a free flow of the blood for a short time.

In membranous dysmenorrhœa the negative pole of the galvanic current in the uterus. The treatments should begin the week before the expected period, and should be repeated every other day, each sitting lasting ten minutes, and a current-strength of 50 to 100 ma. being employed.

Ovarian or tubal dysmenorrhœa is due either to a con-

gested or inflammatory condition of one or both ovaries, or the Fallopian tubes, and is generally the result of gonorrhœal peritonitis, or of infection of the peritoneum after a dirty or septic miscarriage or confinement. The pain usually commences several days before the flow does, and sometimes, but not always, ceases as soon as the flow is well established. It radiates from one or both iliac regions up or down the sides of the body or into the gluteal region or thigh. The flow is often rather scanty. Dysmenorrhœa due to inflamed ovaries may be recognized by the exquisite tenderness to pressure and sensation of nausea accompaning the vaginal examination.

Ovarian and tubal dysmenorrhœa usually require the galvanic current, positive pole applied intra-vaginal, as near the seat of the trouble as possible, negative pole so placed upon the hypogastrium as to include the diseased organ in the circuit: Treatment twice a week for eight minutes; current strength, 15 to 30 ma. Vaginal bipolar faradization is also very useful in these cases for its stimulating and sedative effects. When all pain and tenderness have subsided the poles will be reversed; that is, the negative pole must be attached to vaginal electrode and the positive to the abdominal, and the same rules followed as given for "Pelvic Exudations," which compare.

In all cases of dysmenorrhœa the first object to be attained is a patulous os, so as to obtain a free drainage from the uterine cavity; this can be secured by the negative-pole treatment of galvanism in the cervix, thereby producing dilatation of the cervical canal. Thorough dilatation of the cervical canal assists in removing the uterine congestion, and the use of the current strengthens the uterine supports as well as the vaginal.

In the treatment of the various forms of dysmenorrhœa one point should be kept in mind, namely, that in each and every variety there exists a catarrhal inflammation of the lining of the womb (endometritis), and to effect a permanent

cure of the dysmenorrhœa a healthy condition of the endometrium will have to be established.

After a course of treatment, varying from one to three months, by the above methods, neuralgic pains, uterine fixation, inflammation, and hyperæsthesia and hypertrophy of the mucous membrane will, as a rule, disappear, and the patient be entirely relieved from her dysmenorrhœa.

MENORRHAGIA.

We restrict this term to those forms of hemorrhage pertaining to the menstrual functions. For the treatment of the various forms of hemorrhage accompanying fibroids, metritis, etc., consult those headings. Menstruation may occur too often, continue too long, or be too profuse while it does continue. If permitted to continue this excessive drain will eventually undermine and destroy the constitution. For this condition no line of treatment in any wise equals the application of the galvanic current. It not only often arrests hemorrhage at the time, but so narrows the vascular channels that all the following menstruations, previously hemorrhagic, become markedly diminished in quantity. Place a large electrode over the abdomen and connect it with the negative pole; pass a platinum sound, connected with the positive pole, into the uterus and allow a current of from 20 to 50 ma. to pass for eight or ten minutes, and repeat the treatment twice a week during the intermenstrual period until the flow becomes more normal, then once or twice a month for several months. Intra-uterine galvanism for hemorrhage has the advantage over curettement and the application of caustics in that it does not necessitate the administration of an anesthetic, and is followed by no reaction. Bipolar faradization, either intra-uterine or intra-vaginal, should also be given occasionally. It acts as a powerful tonic to the uterus.

VICARIOUS MENSTRUATION.

This term signifies that the menstrual flow, instead of seeking its natural outlet, the uterus, is excreted from the nose, lung, stomach or breast. In those cases of vicarious menstruation in which there is no dysmenorrhœa, the current from the fine wire faradic current (bipolar intra-uterine faradization) will generally be sufficient to attract a flow of blood to the uterus again and at the same time develop the uterus, which is generally found to be abnormally small. If, however, there is much pain at the menstrual period, the galvanic current (negative pole intra-uterine) will be preferable, because it is an especially suitable remedy for the endometritis, which will in such cases generally be present.

PRACTICAL HINTS.

For those severe forms of neuralgia and neuralgic headaches which many women suffer from at about the cessation of the menopause (forty-eight to fifty years of age) nothing will relieve them so surely as will the faradic current applied by means of an intra-vaginal bipolar electrode. Electricity applied in this way seems to have the power to draw the nervous irritation away from the brain and to start up functional activity in the sexual organs again. In many instances, after a few applications, there appears a watery, sanguineous discharge from the uterus, and then the neuralgic attacks diminish in severity, the intervals between their occurrence lengthen, and eventually they disappear altogether; employ the secondary current, or current from the long, fine wire coil. In those cases where the faradic does not seem to give the desired relief, use the galvanic current: Positive pole on the nape of the neck and negative in uterus, with a current of from 10 to 20 ma.

For those cases which complain of an aching distress and bearing down sensation in the pelvis, not attended by inflam-

mation, but simply an hyperæmic condition, due to lack of tonicity in the uterus and its supports, electricity will prove a great boon. It will relieve the hyperæmic condition, tone up the parts and dispel the pains. Its method of application is as follows: The positive pole of the galvanic current applied high up in the vault of the vagina by means of the carbon ball clay-covered vaginal electrode; the negative pole applied either to the lumbar or cervical region; the sitting from eight to ten minutes; the strength of the current just sufficient to be comfortably borne. Often when a patient comes to the office complaining of the above symptoms, a single application will cause her to experience a sense of well-being and temporary relief from all distress, and if the treatments are continued will eventually result in a complete cure of the case.

Ovarian swelling and tenderness, accompanied by prolapse, dysmenorrhœa and reflex symptoms, form a large class of cases that come to the gynæcologist for relief, and the failure to cure under the old methods of treatment has left as an only resource for these patients either opiates or extirpation. It is just in such cases as these that electricity has proved a blessing to women.

In acute ovaritis and salpingitis employ a vaginal electrode, and place it well into the vault of the vagina on the side of the most pain, or on either side at alternate treatments, if the pain is on both sides. The positive pole should be employed for the active pole; that is, the pole within the vagina. In the chronic form of these affections the poles would be the reverse of the above. In the treatment of a case of ovaritis, the displaced ovary must be replaced, held in position, as nearly as possible, by some support; a wool tampon will usually suffice.

No disease or symptom in the whole list of female ills is so common as is leucorrhœa. Probably no woman ever goes through life without it at some period, and for a variable time suffering from it. It is only when it becomes annoying by its

constancy, abundance, or irritating properties that it attracts attention and causes the patient to seek assistance. For leucorrhœa, no form of treatment will equal the judicious use of the galvanic current. A large negative abdominal electrode; positive platinum electrode applied to the cervical canal and endometrium, current strength, 10 to 20 ma., applied for ten minutes twice a week, and as improvement becomes apparent the intervals between the applications may be lengthened. If, however, the menstruation be scanty, as in neurotic cases, the negative pole must be employed intra-uterine.

When the uterus is bound down by adhesions due to pelvic peritonitis, electricity will often prove of great service in causing an absorption of the inflammatory products, thereby relieving the uterus and allowing it to assume its normal position.

Old adhesions, of long standing, between the uterus and its appendages can be broken up, and the soreness removed by using well-selected interrupted faradic currents. The first object is attained by the employment of the current from the short, thick wire; and the second by the use of the current of tension.

In case of a retroverted uterus bound down and rendered immovable by adhesions, by the employment of the negative pole in the vagina the adhesions will be dissolved and the uterus will eventually assume its normal position.

In chronic inflammation, hyperplasias, and displacements of the uterus either the galvanic or faradic current may be indicated, and both may have to be used to complete a cure.

Electricity properly applied is the best means of correcting mal-development of the uterus and appendages. The muscular tissue can be developed, and the involuntary fibers of the blood vessels stimulated by the faradic current. The galvanic current will cause an increase of blood to the parts, and consequently an increase of nutrition.

Faradization, followed by the galvanic current, is the most

reliable means we have of developing the uterus. In the most pronounced case of atrophy of the uterus, it can be so powerfully stimulated by means of the intra-uterine bipolar faradization that eventually it will attain a depth of two and one-half inches.

Uterine hemorrhage is more certainly controlled by electrical energy than by any other known remedy. In post-partum hemorrhage we can surely obtain instant and permanent contraction of the uterus, no matter how exhausted it may be, by introducing the bipolar electrode and turning on the primary or coarse wire current.

In uterine hemorrhage due to fungous endometritis, where the blood has little tendency to clot, where the patient is in a weak anæmic condition, with relaxed fiber, an enlarged, flabby uterus, no form of treatment will equal an application of the galvanic current (positive pole intra-uterine, negative over the abdomen). In such a case galvanism will do its work most nobly; reducing the uterus in size, restoring normal activity of the circulation, improving the general health, and a few treatments with the primary faradic current will strengthen the supports, and the case will speedily recover.

Hæmatoma and hæmatocele afford a striking illustration of the prompt remedial influence of electricity. Hemorrhage, in a case seen early, may be controlled to a certainty by positive galvanism applied through the vagina. When the case is seen after hemorrhage has ceased, positive galvanism is indicated to control further hemorrhage, to contract the clot which has formed, and to hasten the separation of the serum. If the separated serum is of considerable quantity and produces pain from pressure, it may be withdrawn by trocar and canula, but positive galvanism must be used immediately afterward to contract the capillaries and prevent the recurrence of hemorrhage, and to favor the closure of the sac which contains the fluid. Positive galvanism must be used, however, for some time subsequently to produce a still

further contraction of the clot, and as soon as all sensitiveness has subsided, and all inflammatory action surrounding the effusion has been subdued, negative galvanism may be applied through the vagina to hasten absorption, or, if the case is an obstinate one, absorption may be hastened by negative galvano-puncture of fifty to one hundred ma.

Subinvolution is more successfully and quickly treated by electricity than by any other means. In subinvolution following abortion, when slight hemorrhage continues for days or even weeks, when all our remedies fail us; in cases of too frequent childbirth and all conditions of debility following parturition when the womb lacks its proper contractile power, there is nothing that can relieve so quickly and accomplish such satisfactory results as the use of the faradic current from the intermediate or coarse wire secondary coil.

When there is relaxation of the vagina and uterine supports, bipolar faradization of the vagina will tone up the parts and prove of marked benefit. If the surrounding parts are very sensitive, use the long, fine wire ; if not, the coarse wire coil may be employed with greater advantage.

In the treatment of certain morbid conditions of the endometrium, especially chronic endometritis, uterine catarrh, and membranous dysmenorrhœa, the application of the negative current, by means of an insulated intra-uterine sound, produces far more uniformily good results than any other form of intra-uterine medication. In many such cases that have lasted for years and resisted every kind of treatment previously used electricity will make a permanent cure.

In the removal of the inflammatory deposits and adhesions in gynecology, electricity gains the most glory. It will disperse chronic inflammations, destroy adhesions, absorb exudations, rectify displacements, arrest the growth of fibroid tumors, and restore the pelvic organs to their normal functions and tone. Chronic pelvic cellulitis, exudations and adhesions of long standing, after all inflammatory action has subsided, yield readily to treatment by negative galvanism by means of vaginal or intra-uterine applications.

In those obscure pelvic pains, due to an inflammatory deposit unrecognizable by digital examinations, extending down the sciatic or crural nerves, electricity will often give relief after all other measures have been tried and failed. Compare treatment for "Pelvic Exudations."

In chronic cases, that is, where improvement is seemingly at a standstill, or very slow, electricity will improve the general system, and thus hasten the absorption of the remaining exudation.

Pain and tenderness of uterine origin are often mistaken for ovarian disease. Many a patient has been subjected to an operation on account of these pains who could have been relieved by the fine wire coil or tension current (secondary current), with its sedative influence.

In neurotic conditions removal of the uterine appendages is not only useless, but often leaves the patient worse off than she was before. The neurosis will almost always persist until the accompanying uterine disease has disappeared, and this can best be accomplished by the judicious use of electricity.

Many cases of pain in the pelvis, continuing after the operation for the removal of the ovaries, which the operation fail to cure, can be, as a rule, promptly relieved and eventually cured by prolonged applications of the secondary faradic current to the inside of, or to the neighborhood of, the uterus with a bipolar intra-uterine or vaginal electrode.

In the treatment of the various morbid conditions of the ovaries, in electricity we have an agent which in many cases will accomplish a cure by less heroic means, more safely, and with less suffering than can be done by any other method. Enlarged, tender and prolapsed ovaries can be reduced, their sensitiveness lessened and the ovary caused to disappear from Douglas' cul-de-sac. Even women with all the subjective and objective symptoms of ovarian or of tubal abscess have been cured without any operation whatever, the pus having disappeared either through absorption or inspissation. Drainage of the uterine cavity, and of the tubes, constitutes the chief

object of treatment in purulent salpingitis—purulent inflammation of the Fallopian tubes.

In the great majority of cases, diseases of the tubes are secondary to uterine diseases, therefore to effectually combat tubal disease you must first cure the cause found in the uterus. According to Martin, out of two hundred and eighty-seven patients treated for tubal disease, in more than two-thirds the uterus was diseased.

Small cysts and fibro-cysts of the ovary and in the broad ligament frequently yield readily to negative galvano-puncture through the vagina, some of them requiring only one puncture for their complete removal.

Electricity will have to be employed very carefully where there are indications of cysts or purulent formations in the tubes or ovaries.

For endocervicitis and endometritis galvanism will give the best results; the negative electrode applied to the cervix and the cervical canal, the positive connected with a large abdominal electrode, using a current of from 10 to 15 ma.

In chronic endometritis you will fail to cure the case unless the cervical canal is freely opened. Undoubtedly many of the cases of inflammation which follow intra-uterine treatments of galvanism are due to lack of perfect drainage. After treatments of this kind, if the drainage is not perfect, if the internal os is not completely dilated, you are liable to have inflammation and septic conditions following; therefore, the first principle is to see that you have an opening for the drainage, and then go on and treat with as strong currents as you wish.

Do not attempt to treat chronic congestion of the uterus with electricity when it depends upon a lacerated cervix, and expect from it permanent results; but after the laceration has been repaired and the uterus still remains congested, you can use electricity and expect to obtain good results.

Positive intra-uterine galvanism has proven to be one of the greatest blessings to womankind, controlling uterine

hemorrhage the result of fibroid growths, curing endometritis, and curing or at least alleviating many tubal and ovarian diseases.

In the treatment of hemorrhagic fibroids or fungous endometritis, it is necessary to thoroughly cauterize the entire surface of the uterus. The growth of fibroid tumor is arrested, and it is often made to diminish in size, and symptomatically cured, by electrolysis.

Electricity is a powerful remedy in the various functional disturbances of menstruation; even in young girls, in whom the application of the current externally, in the intervals of the periods or even during the flow, is sufficient to regulate the function, whether the trouble be scanty flow, an excessive one, or spasmodic pain; and recourse need no longer be had, as is too often the case, to harmful drugs or to curettage.

As an auxiliary to the pelvic uses of galvanic and faradic currents, the nutritional, and sedative effects of static electricity are invaluable to the patient. In the backaches of women, neurotic disturbances, headaches, cold extremeties or hot flashes, static electricity will add immensely to the benefit of local treatment. The first, simplest, and unfailing remedy for recent pains of congestion or fatigue is the static breeze. To older and more obstinate cases add the mild sparks for counter-irritation.

Galvanic baths given in a tub, with the current directed through the electrode opposite the hips, will often prove a satisfactory method in treatment of functional derangement of the uterus and ovaries.

For vaginismus apply the negative pole to the vulva by means of a vaginal electrode. Hold the electrode in place with gentle pressure (do not exert any force on the electrode) until it gradually slips into the vagina, and continue the sitting fifteen minutes; current strength 5 to 8 ma. Galvanism will relieve the greater majority of cases; any exciting cause, of course, must first be removed.

Ptyalism of pregnancy is quickly cured with galvanism,

the negative pole applied to the tongue, and the positive pole held in the hand of the patient, or applied labile over the salivary glands on each side. The treatment should be given twice a week, and about 10 ma. used for three minutes.

After confinements, where the milk fails to appear or is very scanty, a few applications of the faradic current will establish it. Place one electrode in the axilla and apply the other to the breast, using a mild current for ten minutes every other day until the milk flow becomes fully established.

Apart from the functional troubles, inflammation and neoplasms, a large majority of patients apply for relief for chronic pain and malaise, the true nature of which is not clear. Here the use of electricity is especially to be recommended as a substitute for the so-called exploratory laparotomy, which too frequently terminates in the removal of ovaries seldom, if at all, diseased. Not only does electricity bring recovery in many of these obscure cases, but it also, even when it throws no light upon the real character of the disease, leaves the patient in good condition for the employment of other treatment.

In gynecological work it is absolutcly necessary that the indifferent electrode should be a large one (6¼ by 9¼ is a good size), so as to dispense the current correctly, thereby preventing pains as far as possible and avoiding cauterization of the skin.

Engelman advises the employment of an electrode consisting of a pliable sheet of lead perforated with holes one line in diameter, one inch apart, and covered with a layer of punk or absorbent cotton, held in place by a thin buckskin or any other material which is a good conductor and absorbent. The electrode must be soaked with hot water (not a saline solution, for in employing currents of high intensities the electrolytic action of the galvanic current decomposes the salt, and chlorine is developed at the positive pole, thus causing more pain), and the super-abundance of which is expressed before it is placed. It is very important that the plate be of very

pliable metal, so as to adapt itself to the undulations of the surface upon which it may be placed. This kind of an electrode is cheaply made, and, as a rule, will answer all the purposes of the costly clay electrode of Apostoli and others.

Now the position of the electrodes is sometimes of great importance. When you desire the inter-polar influence of the current you must place your internal electrode and your external electrode in such relation to each other that the tissues under consideration or treatment will be immediately included between the two poles ; that is to say, if you are treating the diseased condition of one side of the pelvis, place your vaginal electrode at the most accessible place on that side of the vagina and your external electrode on that side of the abdomen, thus concentrating your current to one side rather than disperseing it over the whole surface of the abdomen externally, for by this dispersion you would lose much of the current as well as the effect. In like manner, if it is more convenient to place the external electrode on the lower part of the spine the position must be such that the diseased structures will be included between the two poles. For electricity in passing from one pole to the other, to complete the circuit, will, as a rule, take the most direct route. But when you desire only the local action of the active pole the position of the external electrode is a matter of indifference.

Avoid unclean electrodes, especially vaginal and intra-uterine, and before using either—be they ever so carefully washed—dip them in some antiseptic solution, and rub off thoroughly with a piece of absorbent cotton. Always wipe out the vagina with cotton dipped in a weak antiseptic solution, and never introduce an intra-uterine electrode without first removing all of the secretions from the os.

After an application to the endometrium make it a rule to invariably use an applicator wound with absorbent cotton, and dry the endometrium as far as possible ; then, by removing clotted blood and loose particles of mucus, you prevent danger of sepsis.

When the galvanic current is employed, the vaginal electrode should be covered with absorbent cotton or chamois to prevent it from causing an eschar.

When the positive pole is used in the vagina with a current of 100 ma., or over, it is better to dip the electrode in a solution of bicarbonate of soda so as to neutralize the acids that collect at the point of contact, thereby preventing the usual caustic action.

When employing galvanism in the vagina, a much higher intensity can be given without causing caustic effects when the vaginal electrode is connected with the negative than when connected with the positive pole. With the negative pole 200 or 250 ma., can be given for five minutes without a caustic effect; whereas, with the positive pole, it is impossible to use in the vagina 100 ma., for the same length of time, without producing active cauterization.

On account of the small amount of resistance to the current passing through a moist mucous surface, a current of enormous strength, as compared with that which would be necessary to cauterize the skin, is required to produce any cauterization effect on a mucous surface. A continuous current (negative) of 200 ma. may be applied without pain in a gynecological treatment when *slowly* increased to that intensity; *rapid* increase is very painful, and *sudden* making or breaking would be almost unbearable.

Electricity has been found of benefit in differential diagnosis of the diseases of the female genital organs. Where the uterine adnexa are healthy, a continuous current (galvanic) of from 100 to 200 ma. can be applied without developing unfavorable symptoms; when inflammatory disease is present there is intolerance to this current, and pain or fever always follows.

It is often the case that a nervous pain simulates a true inflammatory one. Apply vaginal or intra-uterine faradization; if the pain disappears or is much relieved in severity, it is not due to a lesion of the appendages, but is simply

nervous; but if after one or several applications the pain is modified but little or not at all, it is certain that it is due to an inflammation of the appendages.

Electricity being an essentially conservative method, it brings to the aid of the surgeon most precious assistance in doubtful cases by determining with the rigorous exactitude of an experiment in physics, the indications and opportunity for radical intervention.

As to the value of electricity às a means of making a differential diagnosis of the diseases pertaining to the pelvic organs of women, Dr. Apostoli offers the following hints:

1. The faradic current of tension applied to the uterine cavity relieves, for a longer or shorter time, all ovarian pain of nervous or hysterical origin: but remains powerless, or nearly so, in cases of ovarian pain caused by inflammatory lesion of the peri-uterine tissue or of the appendages.

2. The galvanic current applied to the uterine cavity in doses gradually increasing from 50 to 120 ma., bearing in mind the individual susceptibility and tolerance, will be almost always supported without much pain during the seance, and without febrile reaction afterward, if the parts adjacent to the uterus are free from inflammation.

3. All acute peri-uterine inflammation (of the pelvic cellular tissues, of the peritoneum and especially of the appendages) will cause the galvanic current to be badly borne when it passes 40 or 50 ma., and will cause intolerable pain and febrile reaction when carried beyond this intensity.

4. The tolerauce for the galvanic current is generally proportionate to the extent and gravity of the lesions referred to, and increases with the intensity of the current employed —especially where it passes 40 or 50 ma.

5. All inflammation of the appendages which is curable (symptomatically at least) without radical operation will bear the galvanic current better and better, and there will be a corresponding improvement of the prominent symptoms,

such as pain and hemorrhage. The intolerance noted at the beginning of the treatment gradually disappears.

6. All grave inflammatory lesions of the appendages, and notably all suppurative processes which are incurable (even symptomatically) by conservative means, show the same intolerance from the beginning to the end of the treatment which was noticed at first, and which is apt to increase instead of diminish if the treatment is continued.

7. Thus, the simple study of the tolerance or intolerance of the intra-uterine galvanic treatment, and especially of the post-operative pain and fever occurring on the evening of or the day following the treatment, enables us to make the diagnosis. It also, in four or five seances, given twice weekly, informs us of the condition of the appendages, of their possible inflammation and its degree, and in this way it lessens the number of laparotomies and exploratory incisions.

8. The same study of the so-called galvanic reactions also informs us rapidly (in five to ten seances) of the curability of these inflammatory lesions which the electric current has demonstrated, and in consequence of this it tells us in one case to abstain from operation while in another it shows an operation to be urgent.

9. Independently, in fact, of the great therapeutic service which it renders every day electricity serves as a touchstone; it assists us in diagnosis, and thus directly serves the interest of surgery, in one case showing an operation to be useless and dangerous, in another that its necessity is urgent. Thus many laparotomies, so-called exploratory incisions, and mutilations, practiced without due deliberation for the relief of rebellious ovarian pain or for lesions of the appendages of uncertain nature, should be, from this time forth, delayed or formerly proscribed until all the resources of *faradic sedation* on the one hand and of the *intra-uterine galvanic effect* on the other have been tried.

10. *En resumé*, gynecological electro-therapeutics, carefully, methodically, and patiently applied, instead of being opposed to the progress of surgery, comes to its aid.

X-RAYS.

(*Roentgen Rays.*)

When Dr. Wm. Konrad Roentgen discovered the x-rays he gave them this name because he did not know what they were. The letter "X," it is of course well understood, is used in algebra to represent an unknown quantity. For this reason Prof. Roentgen modestly termed that special form of radiation from a Crookes tube noted by himself the X or unknown ray. He called it a ray because of the regular shadow it forms on the screen. Various theories have been presented to explain the phenomena of the x-rays, and the most satisfactory is that they are some form of wave motion; that these wave lengths are so short that they can not be taken up by the retina of the human eye, and that, by impinging upon certain fluorescent substances, they are lengthened so that they become visible. Roentgen claims that the x-rays are not identical wth cathode rays, but that they are generated by the cathode ray at the glass wall of the discharge apparatus—that is, at the point on the wall of the tube where the cathode rays strike and fluoresce most decidedly. Later experimentation has shown that not only is the fluorescent spot on the glass considered to be a source of the x-ray, but also any substance place within the tube against which the cathodic stream impinges, is in like manner a source. Hence, undoubtedly, the x-rays do not start from the cathode or from anything attached from the cathode, but do start from a surface upon which the cathode rays strike, whether it be an actual anode or only an "anti-cathodic" surface; best, however, if it be an actual anode.

Of the nature of cathode rays, Swinton says: "Cathode rays are generally believed to consist of atoms or molecules of residual gas, which, being similarly electrified to the cathode, are repulsed by the latter, and travel at an average velocity not much less than one-twentieth that of light, the velocity depending upon the exact potential of the cathode and also upon the degree of exhaustion of the tube, upon which depends the path free of the molecules, that is, the distance a molecule can travel without coming in contact with another molecule."

The x-rays differ from ordinary light not only in their power of penetration of substances opaque to the light, but also by the absorption of the rays by glass and other crystalline substances which are pervious to light. In other words, certain substances which are transparent, or nearly so, to ordinary light, are opaque to the x-rays, and *per contra*, certain substances opaque to ordinary light, are more or less transparent to the x-ray.

GENERAL REMARKS ON THE X-RAY.

The x-ray is a form of radiation having characteristic and distinctive properties. It has the property of causing various substances to fluoresce, affecting the ordinary photographic plates, like light (although itself invisible), and of penetrating opaque bodies in various degrees, according to their density and relative thickness; platinum, lead and silver being quite opaque, while aluminum, wood and paper are quite transparent. Carbon in any form—as diamond or as coal or graphite—is almost perfectly transparent to the x-ray, but lead is almost totally impenetrable by it; hence the great advantage of the x-ray in searching for bullets in the body. In general, it may be said that the greater the density of the object the greater its opacity to x-ray.

The softer tissues of the body are easily penetrated by the x-rays, as also cartilage, but bone absorbs the ray to the extent of causing a distinct shadow when surrounded by the

PLATE I.—Showing a normal hand with a ring on third finger. Metal being denser than bone casts a darker shadow, thereby hiding the bone shadow. The white spaces between the joints represent the cartilages. One thing which will arrest attention is the great distance which apparently intervenes between the bones. This is due to the fact that the articular cartilages being easily traversed by the rays do not cast a shadow. Notice especially the sesamoid bones—the small dark objects lying near the joints. Time of exposure, 45 seconds; distance of tube from plate 16 inches.

softer tissues. The x-rays will penetrate flesh and bone, but will penetrate flesh much more easily than bone. Therefore, if the hand is placed between the fluoroscope and the Crookes tube and the x-ray is projected through the hand, it will be seen by the fluoroscope that the bones cast more of a shadow than the transparent flesh and stand out in bold relief.

The shadows of the bones of the cranium, as well as those of the pelvis, have up to the present time made it well-nigh impossible to locate a neoplasm, either cerebral or abdominal, with the radiograph or fluoroscope. Foreign substances of a metallic nature can, however, be readily detected.

By means of the x-rays we can obtain pictures of the bony structure of any part of the body and show the presence, not only of foreign substances of a metallic nature, but also of calcareous deposits or other substances that are opaque to the x-rays.

The x-ray is of great value in serving to make an exact diagnosis of the existence or non-existence of foreign bodies, and if present their locality. The location of foreign bodies, splinters, broken glass, needles and bullets is demonstrated with certainty possible in no other way, and many a long and painful dissection is thus avoided. The older methods of probing for bullets, with consequent danger of carrying infection to the wounded parts, should be abandoned in favor of x-rays. (Fig. 18.)

The x-rays give us a most reliable method of ascertaining the condition of the vessels, and this in nearly every part of the body. Calcification of the arteries can be seen with great distinctiveness. Thoracic aneurisms are recognizable in their early stages. In certain cases it is the only method of diagnosing with certainty aneurisms of the aorta. In the study of aneurisms and their pathological expansile motion, as observed by the fluoroscope, there is a definite addition to our knowledge. The arteries and veins of dead bodies may be injected with a substance opaque to the x-ray, and thus their distribution may be more accurately followed than by any

possible dissection. By filling the stomach with a solution of bismuth its outline can be clearly made out.

By means of the x-rays we may obtain indications of solid tumors and enlargement of certain viscera. The kidneys can be made out, and if they contain calculi these can be found. The relative transparency of calculi to the rays, however, has made this branch of investigation less certain than with denser substances. Stone in the bladder, in children, is usually readily detected. The location of coins or other metallic substances in the œsophagus has become an easy matter. Their exact locatiou can quickly be determined and thus facilitating the operation for their extraction.

Ophthalmology is undoubtedly indebted to the x-ray, as it has added another accurate method in diagnosing of the injuries complicated by the presence of foreign bodies. When there is a foreign body in the eye it is better to take two exposures from different points and deduce the position of the foreign bodies by geometrical calculation.

The value of x-rays in obstetrics, both during pregnancy and in the absence of gestation, has been investigated by Mullerheim. He maintains that by the use of the rays the various forms and degrees of pelvic deformity, such as arise from rachitis, osteomalacia and spondylolisthesis may be detected and appropriate treatment instituted in case of subsequent pregnancy. It is possible by this method to determine accurately the distance between the posterior superior iliac spines, the breadth of the os sacrum, the distance of the lumbosacral crista spinosa from the posterior superior iliac spines, and the distance from the middle of the promontory of the sacrum to the sacroiliac symphysis. Not only can the presentation of the fetus be determined, but also the size of the fetal head and the dimensions of the pelvis.

By means of the x-rays adult bones can be readily distinguished from those of children, or where the bones are not fully ossified ; also the diagnosis of growths composed wholly or in part of bone. The character of osseous tumors, their

PLATE II.—Showing a normal hand. Time of exposure 30 seconds; distance of tube from plate 20 inches. Note the shading of the skin and muscles and the general outline of the hand. By comparing this figure with Plate I, a marked contrast will be observed. In Plate I it will be observed that the outline of the muscles and skin has nearly disappeared, and that the bones present a lighter appearance. This is due to the time of exposure being longer and the plate being closer to the tube. The longer the exposure the more does the flesh shadow disappear.

shape, size and manner of attachment are easily made out. Gouty lesions of the bones and periosteum can also be readily recognized. Irregularities in outline from erosions, necroses, bony deposits, and in fact all forms of bone disease attended by change in form, widen still further the scope of the x-rays. (Fig. 19.)

It is possible to detect an osteosarcoma in the early stage as soon as the density and contour of the bone is affected. Such a growth may be watched from week to week; the bone may be seen to gradually melt away before the invading neoplasm. The same is true in tubercular disease of the bone.

In cases of osseous tumors of the antrum of Highmore, as, for instance, an osteo-sarcoma of the antrum, and especially in the cases of foreign bodies, where these have a higher resistance to the rays than the bone, or a metallic substance, the x-rays would undoubtedly prove of great assistance.

The x-rays are of great value in gaining early diagnostic signs of tubercular and other allied diseases. By this means it is possible to detect consumption, the greatest enemy of the human race, before the ravages of the disease have destroyed all hope of repair.

The employment of the x-rays makes it possible in certain cases to discover commencing changes in the lungs at a period when other methods of clinical investigation give no indication. In other cases it defines the extent or reveals the importance of a lesion insufficiently disclosed by auscultation or percussion. Again, it enables the practitioner to reject the hypothesis of tuberculosis in cases where symptoms and clinical signs of doubtful import puzzle the clinician; while at the same time it often enables him to trace to their true cause general disturbances which clinical observation has failed to detect. In a word, it makes the evolution of the disease visible to the eye.

It is well known that caseous phthisis following catarrhal pneumonia is often rapidly fatal, but if prolonged to a period of chronicity can be cured. This form of consumption is so

gradual in its onset that the early symptoms evade all hitherto known methods for diagnosing the disease; but now the x-ray will reveal that which was formerly impossible to know.

Cavities of the lungs can be recognized as a clear area, and exudations by a dark shadow. In pleurisy it is possible to fix the limits of the effusion, and the movements of the diaphragm can also be observed.

Whether the x-rays do or do not possess therapeutic properties is still an undecided question; much has been claimed, nothing has been proved. No one has yet produced results that are indisputably the effect of these unknown rays; and until it has been proved that this therapeutic influence is not due to electrical stimulation, and the destruction to its devitalizing action, it ought not to be attributed to the x-rays. Time and again wonderful properties have been claimed for them, therapeutically, but these claims have not proven true. Even in those cases that have been benefited by the application of the x-rays, the benefit has undoubtedly been due to the static electrical charge rather than to any properties of the x-rays.

As for the action of the x-rays on bacteria, often asserted and often denied, the consensus of opinion seems to be that the x-ray, proper, has no germicidal action whatever upon them, but what has been claimed for the x-ray is simply the influence of the static electrical discharge which accompanies the x-rays.

The use of the word x-ray to the word burn is a misapplication of the term and causes a false impression. The x-rays themselves excite no appreciable heating effects, and consequently do not burn. All evidence seems to point to the conclusion that the lesion is due to the direct effect of the electric currents upon the tissues and fluids. That electricity is capable of devitalizing and destroying tissue is well known. It must be first proved that the x-ray dermatitis is not the result of this devitalizing action before we have the right to attribute it to an unknown action of the x-rays.

PLATE III.—Arteries of a child injected with mercury. (By Dr. A. V. L. Brokaw). The study of injected vessels by means of the X-Rays is particularly interesting, the relationship to the osseous system showing far better than dissections. It must be remembered, however, that a print can in nowise be compared with the original negative for distinctness, for many of the finer points are lost in the print.

PLATE V.—Showing an osteo-sarcomatous growth on the femur. The protuberance to the left is the patella; just back of it the bony tumor is plainly visible. Time of exposure 3 minutes; distance of tube from plate 20 inches.

With such tubes as are now in use and with the relatively brief exposure needed, the danger of causing x-ray burns or other injury is practically of no importance. There is in fact no danger except in exposures at quite short range and lasting for an hour or more. (Fig. 20.)

As the static machine produces a current of high potential and infinitely small amperage and does not produce electrolysis or chemical effects there is very little danger when employing a static machine. It is when coils are used that there is danger of causing the so-called-x-ray burns. Even when coils are used, by the interposition of an aluminum screen attached to a grounding wire between the patient and the tube, the danger of producing x-ray burns has been reduced to a *minimum*, for the static charge of electricity, which in all probability causes the injury, is collected on it and conducted to the earth. As this screen is penetrable by the x-rays the fluoroscopic or radiographic qualities of the rays are not impaired.

Leonard gives the following propositions on the so-called destructive and therapeutic action of the x-rays:

1. Static electric currents are capable of producing all the therapeutic and destructive changes ascribed to the Roentgen ray.

2. A static field of sufficient strength is always present, when a tube is said to be capable of producing these results.

3. Why should we ascribe to the Roentgen ray therapeutic and pathologic effects which the static charges, always present, are capable of producing?

4. It is impossible to produce a "burn" when a protecting shield of aluminum is employed which collects the static electricity and conducts it by a grounding wire to the earth, although the Roentgen efficiency of the ray is unaltered.

5. It is therefore reasonable to conclude that the devitalizing action attributed to the Roentgen ray is due to long continued or intense static charges or currents, while the thera-

peutic action is the stimulating effect of a mild and judiciously employed amount of a static charge.

6. The therapeutic results obtained are of undoubted value, but that value will be enhanced and its employment facilitated by the recognition of its true physiological source—the static electric current.

Knowledge of the x-ray is spreading rapidly. We have every reason to believe that fully one-half of the possibility of this wonderful light is yet unknown. As it has become better known it is more frequently employed, and each improvement in its construction has marked a new step toward a popular career.

Every hospital should be equipped with an x-ray machine. It would be an excellent routine practice to have photographs of every fracture, taken after reduction and application of the splints, to be sure that the fragments are in the best possible position for union. These x-ray photographs can be taken for this purpose through the dressings. If the position is not correct it can be changed before any attempt at union takes place. The limb should be examined in the course of a week or ten days to ascertain whether the position of the bones is still correct. This method would prevent many cases of non-union and would save many a surgeon's reputation and possibly a suit.

It is the duty of every civilized nation to supply its wounded with an x-ray apparatus, among other surgical aids, not only at base hospitals, but close at hand, wherever troops may be fighting and exposing themselves to injury in the performance of hazardous duty.

THE APPLICATION OF THE X-RAY TO SURGICAL DIAGNOSIS.

Great as is the interest which the x-ray has excited in the minds of scientists throughout the world, still greater is its interest to the physician and surgeon, for in its application to

medicine and surgery lies its greatest field of usefulness to humanity.

The explorations of the mysteries of the human body have ever been the desideratum at which the physician aimed, and while many devices have been formulated which materially aid him in his work it is the revelation of the x-ray which has given to science its most valuable means of diagnosis. No surgeon can dispense with this diagnostic aid, and the same necessity in the near future will appeal to the physician.

The x-ray is proving invaluable to the surgeon. It not only enables him to determine the nature of a fracture or a break, but also abnormal conditions; it enables him to determine whether such fracture or break is properly set and whether such abnormal condition can be corrected with surgical interference; it is of great value in the demonstration of integrity whenever suspected fractures and dislocations do not exist.

The x-rays are often as useful in demonstrating negative conditions, such as suspected fractures, dislocations, bony ankylosis, foreign bodies, etc., as in those cases in which fractures, foreign bodies, etc., are present. It will enable the surgeon to make accurate diagnosis in many cases in which accuracy was impossible without its use; also to avoid serious mistakes in the investigation of fractures and dislocations.

By this means it is possible to detect and diagnosticate not only fractures but also dislocations, and what is very important to decide in a given case, whether it is a fracture or a dislocation, or both together, as often happens.

Broken bones, or those improperly set after being broken, as well as dislocations, can be disclosed as clearly as if the flesh were stripped from that part of the body in which they are located. In united fractures, especially of the humerus and of the forearm, the point of union may be easily ascer-

tained. It may be seen whether a bone is totally or only partly severed—a matter of great importance.

By the employment of the x-rays the exact condition in obscure cases of fractures is shown; many fractures which have been described as rare have been shown to have been rarely detected. In other instances, fractures which were supposed to have been properly reduced have been shown by the use of the x-rays to be still the seat of deformity. The exact determination of the form of fracture and the recognition of minute comminuted fragments have rendered coaptation more precise and the result of treatment more perfect. (Fig. 21.)

The progress of the union of the bone, after it has been set in splints, may be studied in its various stages; or even the correctness of the setting of the bone may be determined and rectified if wrong. A fracture can be examined, after being set and bandages applied, so as to be certain that the ends of the bone are in apposition. Surgical dressings, cotton and the ordinary bandages interpose no obstacle to the passage of the rays. It is a great satisfaction to both parent and physician to see that, after the splints are placed, the bones remain in proper position so as to insure a perfect union of the bones and a useful limb. It must often be true that when we imagine we have placed the fragment of broken bone in a perfect apposition they may not be so after all.

In recent fractures—chiefly of the upper extremities, the clavicle and ribs—the exact position of the fragments before and after reduction can be made out, and a faulty adjustment may be rectified at once.

In old fractures the information to be gained by the x-rays is invaluable, for only in this way can we determine the position of the fragments, the point of impingement, and the cause of impaired functions. Hence, as in most x-ray work, the fluoroscope gives vastly more important information than the radiograph, because one sees in succession the parts from every point of view.

In those cases of non-union of the bone after a fracture,

when the physician, by the ordinary methods of examination, is positive that the ends of the bones are in perfect apposition, it is a great satisfaction to know that the non-union did not depend upon any faulty position of the fragments, and this can be easily ascertained by a fluoroscopic examination. Bony union in fractures takes, in some cases, months or years to unite—some never completely ossify. An incompletely ossified bone must not be mistaken for a fracture, or vice versa.*

Fractures and deformities may exist which, from the position, line of fracture, effusion of blood, or character of deformity, will not furnish evidence in a radiograph or fluoroscope. Therefore, failure to see the fracture or deformity, by means of the x-rays, is not evidence that they do not exist, if other symptoms point to their being present. Again, failure to get an x-ray, or to get a fluoroscopic view, will, in some cases, occur from faulty manipulations: Machinery being out of order, insufficient power, or adverse atmospheric conditions; hence, failure may occur at any one time and success at another.†

As a rule, any lesion of the vertebræ can be immediately recognized by means of the x-rays. In scoliosis we can obtain information which is, usually, only learned post-mortem. A radiograph will show clearly the dorsal and lateral aspects, the various deformities of the body, pedicle and arch of the vertebræ; also the bony union of several vertebræ, the existence of osseous products at the periphery, which teach us the

* Non-union is frequently caused by the protrusion between the bones of a piece of muscle or a loose piece of bone, in cases of comminuted fractures, thus preventing the close apposition of the fractured ends and resulting in caries of the bone. By a careful examination of these bones with the x-ray such a condition could be easily detected, and, if necessary, the limb should be opened up and all obstruction to close apposition of the bones removed.

† The x-ray may be made to exaggerate the existing deformity or displacement, from carelessness or purposely, and in suits for damage no radiograph should be accepted unless made by a disinterested operator; also, there are cases in which the radiograph seems to show a fracture when it does not exist; and again existing fractures do not always show. These are points of extreme importance that it is well to remember.

cause and degree of rachitic rigidity, and consequently fix the prognosis and curability of some old cases of scoliosis.

In Pott's disease and in scoliosis a radiograph will demonstrate with great precision of detail the image of the configuration, the position of the rachitic vertebræ, the number of vertebræ affected, the extent and depth of the tuberculous lesions, as well as the alterations in the neighboring tissues and organs; and at an advanced period of Pott's disease the radiograph indicates the extent of the lesion, the importance of loss of substance, the existence of sequestra, of tuberculous caverns and the degree and cause of rachitic curvatures.

The radiograph is in concordance with the proof furnished by the study of anatomical specimens, in demonstrating that, in a great number of cases of Pott's disease, above all in recent cases, that consolidation (the union of one or several vertebræ by a peripheral or inter-fragmentary callous) in good position, by junction of the vertebræ, is frequently obtained.

By means of the x-ray the initial tuberculous lesions (tubercular foci) may be revealed long before they would present objective and subjective symptoms of sufficient degree to warrant a positive diagnosis.

By means of a radiograph or of a fluoroscope a much better idea of the relations of the bones which compose the joints can be obtained than could be from prepared skeletons. Dislocations, old and new, of the extremities can never be overlooked if a fluoroscopic examination is made. The slightest variation from the normal is immediately visible in an extremity.

In examining the joints, one thing which will arrest the attention is the great distance that apparently intervenes between the bones. This is due to the fact that the articular cartilages, being easily traversed by the rays, do not cast a shadow. The character of injuries about the articulations, many of which, particularly near the elbow, if not seen before the swelling has taken place, are not recognizable by

Plate IV.—Showing a broken needle, the point being to the right of the metacarpal, the shaft of the needle lying to the left of the bone. Notice especially the distinctness of the eye of the needle.

palpation, even under æther, are very clearly diagnosed by means of the x-rays.

It is easy, with this aid, to diagnose between an enlargement of the bones and a swelling of the soft parts in chronic diseases of the joints; also to determine if ankylosis is bony or fibrous. It is often important to decide whether the fixed posture of a stiff joint which has been injured by fracture or disease is due to a growth of bone or growth of soft tissue, both of which may equally obstruct its movements, while one is far more difficult to relieve than the other. The bony bands or adhesions are opaque to x-rays while the fibrous bands are transparent.

In many instances, by means of the x-rays, fractures that lie wholly within the capsule of the joint and thus escape detection, are distinctly shown and are rendered amenable to treatment other than for "bad sprains." The x-rays have shown that in the majority of so-called "sprains" there was actually either fracture or dislocation of some one or more of the small bones. The treatment should be fixation, in order to prevent false joints, exostoses, etc., thus leaving permanent impairment of functions.

The employment of the x-ray has led to a satisfactory diagnosis in cases of swollen feet, a complaint very frequently met with in individuals who are compelled to walk a great deal, such as infantry soldiers. This swelling is frequently unaccompanied by any outward, visible sign. An examination made with the aid of the x-ray not infrequently shows the trouble to be caused by a fracture of the middle metatarsal bones. (Fig. 22.)

In fractures in close proximity to large joints the x-ray has been of great value in ascertaining the direction of the line of fracture, whether or not the fracture extended into the joint, and whether there is any impaction.

The x-rays will render valuable service in that most common and difficult of all fractures—Colles' fracture. The x-ray has shown that a much greater variety of types of this

fracture (which represents ten per cent. of all fractures) exists than was ever anticipated before.*

The occasional failure to detect a dislocation of the elbow—a mistake with which the most experienced are sometimes confounded—is impossible if the parts are carefully examined with the fluoroscope. The excuse that the conditions in a fracture-dislocation about the elbow can not be determined, by reason of great swelling of the soft parts, will not in the future prevail. An examination with the fluoroscope, or the positive evidence of a radiograph, will establish with certainty the conditions present, and thus enable the attending physician to make a prognosis as to the future of the joint, thereby in a measure protecting himself from the all-to-frequent damage suit.

The x-ray renders valuable service in the study of alterations of the articulations of the hip which are accessible with difficulty to clinical exploration because of their depth, and the thick muscular mass that covers them. It is particularly at the beginning of coxalgia (hip-joint disease) that this method of investigation permits certain diagnosis, and inversely to establish the fact of the integrity of the joint in false coxalgia. As respects treatment in such a case, the x-ray furnishes valuable indications by making it possible to recognize the exact seat of articular or osseous lesions, to de-

* Dr. Carl Beck, speaking of forty-four cases of Colles' fracture that he examined by means of the x-rays, says: As far as my own experience is concerned, I must admit that I never saw a case in which the diagnosis made before a skiagram was taken was not more or less modified thereafter, especially when considerable effusion and swelling were present. Of forty-four cases subjected to x-ray examination, most of the skiagrams revealed conditions not thoroughly anticipated when examined by the usual method. One most surprising feature was that in nineteen of these cases *a distinct transverse fissure above the capitulum ulnæ* existed, without causing any apparent symptoms. In seven cases the styloid process of the ulna was entirely broken off. In some instances besides the typical transverse fracture there was also a vertical fracture of the radius, which reached into the radiocarpal joint. In fourteen cases there was no displacement in spite of the great extent of the lesion, the periosteum of the dorsal surface apparently having kept the fragments together.

tect displacements, deformity of the femoral head and the pelvis, the presence of sequestra or purulent collections and peri-articular modifications and changes.

Radiographs taken at different stages of coxalgia show the following lesions: Atrophy of the femur and of the pelvis on the side corresponding to the coxalgia; light color of the whole femur, indicating lesions of the full length of the bone; deep color, indicating fungi or the presence of cold abscesses; spongy bone with small anfractuous cavities; disease of the neck of the femur; lesions of the cotyloid cavity; dislocation or partial dislocation of the head of the femur. By following these deductions, an exact diagnosis of the affection and its peculiarity may be made. By means of the x-ray coxalgia may be distinguished from osteo-myelitis peri-articular lesions, and the different varieties of arthritis.

The painlessness of this diagnostic method, its certainty and harmlessness, make it of great value and almost a necessity if the surgeon would treat fractures involving joints with the greatest care and precision. The study of unusual joint lesions, dislocations, fractures and the differential diagnosis of obscurities in the osseous system demand, for intelligent management, x-ray examinations.

THE VALUE OF X-RAYS IN THE DIAGNOSIS OF PULMONARY AFFECTIONS.

The application of the x-ray to medical diagnosis is far more difficult than its application to surgery, for here the observer must deal with relative opacities of structures which vary from one another by only slight degrees.

In the diagnosis of intra-thoracic diseases it is a fact that, as an adjunct to the methods of physical diagnosis, most positive information is given to those capable of interpreting fluoroscopic appearances. The chief points noted by fluoroscopic examinations of the thorax are: (1) The presence of dark areas in tuberculosis, pneumonia, carcinoma, pleurisy

and empyema—a collection of blood or pus or other fluid in a cavity; (2) the occurrence of abnormal brightness in emphysema and pneumothorax; (3) restriction of the movements of the diaphragm and its altered position; (4) the outlines of the heart, and whether or not there is pericardial effusion.

To examine the chest, seat the patient in a chair without a back; then place a Crookes tube within a few inches of his back, with a dark cloth placed over the tube and his shoulders so as to concentrate all the light on the chest. Then the operator seats himself in front of the patient with the fluoroscope in his right hand; the fluoroscope is pressed firmly against the anterior and upper part of the chest, over the region of the apices, then passed up and down the whole thoracic region. It is important not to take the eyes from the instrument, sliding it over the chest, lest fine points or comparisons be lost.

In studying the various pulmonary lesions considerable practice is necessary before the eye can appreciate perfectly the fine appearance of the shade and outline; appearances which at first were uncertain and barely perceptible soon show themselves plainly; also, a great deal depends upon the intensity and steadiness of light and the amount of muscular and adipose tissue intervening between it and the fluoroscope.

Practice and knowledge of the fluoroscopic picture of a normal thorax are necessary for success. Every operator should early become familiar with the fluoroscopic picture of a normal lung. (Fig. 23.)

In health the lungs appear in the fluoroscopic picture as light areas. In disease, on the contrary, the lungs are not easily traversed by the rays, and in consequence we find opaque areas, which may indicate a tuberculous patch, a neoplasm, a hemorrhagic infarction, or consolidation from whatever cause. If, for instance, in cases of emphysema, in which the lungs are more dense than normal, or in pneumothorax, the normal brightness of the lungs is accentuated. The

brightness of the lungs will vary not only in different individuals, but also in the same individual. The lungs are brighter during inspiration than expiration. Obese and muscular individuals show a pulmonary area less bright than those of reverse development. On account of the small mass and larger size of the lungs in relation to surrounding structures, very fine shadow pictures may be obtained, showing the size, position and relative thickness of the organs. A cavity can only be made out when the lobe in which it is rests comparatively quiet during respiration.

By means of the x-rays the amount of lung involved can be much more accurately told than by physical examination. The diagnosis of tubercular deposit in the lung depends on two conditions: (*a*) on the increased shadow cast; (*b*) the restricted movement of the diaphragm.

The introduction of the x-ray as a diagnostic agent has widened our knowledge to the point, at least, that early infiltrations can be detected in the lungs when no known physical signs could demonstrate their existence. It is not always possible to make a positive diagnosis by means of auscultation and percussion of pulmonary tuberculosis at all times in its incipiency. In fact, considerable impairment of the lung may exist without physical signs to warrant a diagnosis. The changes sometimes go on for a long time with increasing infiltration of the lungs without a noticeable change in its sonority or modification of the vascular murmur.

Slight haziness indicates the beginning of tuberculous infiltration, and may or may not be accompanied by dulness. It is often the case that a slight haziness may be observed in spots which may at the time show no other physical signs of disease, but which upon later development give out all the physical signs of a tuberculous deposit.

In cases of effusion the condition of the apex in regard to transparency on the affected side must be carefully investigated. Even a slight degree of opacity in the region of the apex is important in regard to prognosis. In cases of slight

infiltration of one or both apices there is a haziness or fog between the light and the observer, the clavicle in other instances appearing to have a gauzy veil thrown over it.

Decided shadows indicate consolidation, the extent of which is in direct relation to the comparative density of the shadow thrown on the fluoroscope. When there is marked consolidation the transmitted light is relatively less, the edges of the clavicle are indistinct or the bone may be invisible. When there is present the same pathological condition at both apices it is an easy matter, by comparing the two sides, at once to decide upon which the disease has made the most progress.

Comparative shadows at the apices are generally seen more distinctly from behind than in front by directing the patient to bring his shoulders forward so as to separate as widely as possible the scapulæ, and then placing the fluoroscope directly over the spinal column.

In cases of complete dulness, for instance, to the second intercostal space, with relatively less dulness for one or two intercostal spaces below, a dark shadow will be seen over the first named region, which will gradually shade off consecutively with haziness and normal reflex of light below, the area of haziness corresponding to the limits of relative dulness.

Monnell advises the following method if it is desired to accurately define the limits of an infiltrated lung: A metal rod may be placed evenly against the chest walls in front or behind, and moved up and down simultaneously with the fluoroscope until its outline becomes more distinct, which will indicate that the upper and lower borders of the consolidation have been reached. If a pencil mark now be made along the edge of the rods and subsequently percussion practiced, the area of dulness will be found between the lines.

Effusion at the base of the lung is shown by a thick shadow which hides the diaphragm, and below is lost in the obscurity of the abdominal mass, and above is limited by a zone of penumbra (an incomplete or partial shadow) directed obliquely from above down, from the axillary region to the

vertebral column, or in the shadow of a curve concave at the upper border. Examinations at intervals of a few days will show the variations in the extent in the liquid effusion by variations in the extent and form of the shadow, and thus aid in establishing a correct diagnosis.

An intense opacity of generally rounded outline occupying the middle part of the lung in which the upper and lower parts have almost retained their normal clearness suggests an interlobar effusion. The x-rays are particularly useful for the detection of these central lesions, which on account of the depth at which they are located are apt to be overlooked.

Confluent pulmonary infiltrations with a tendency to softening and ulceration give rise to almost complete opacities; these are darker in the case of lobar infiltrations, and lighter in the case of lobular infiltrations. The intensity of the shadow is proportional to the defect in the penetration of air into the lungs; if the lesion forms a compact, voluminous mass absolutely impenetrable by the air, the darkness shown on the screen is complete; if there are a number of little nodules separated by parts still permeable by the air, the general opacity is less intense, and on the dark ground are to be seen deeper shadows corresponding to points completely caseated.

The pneumonic confluent form of acute tuberculosis reveals itself on the fluoroscent screen by complete opacity of the diseased parts; this is explained by the fact that at these points the lung is no longer permeable to air.

Tuberculosis may begin by an attack of diaphragmatic pleurisy, the symptoms of which are so slight that the only proof that the pleura are involved and that the case is not merely one of intercostal neuralgia is supplied by the x-rays, which show the thickening, diffusion and immobility of the diaphragmatic shadow. If the case is one of dry pleurisy with "stitch" in the side, but without any decisive physical sign, fluoroscopic examination shows superficial opacities quite close to the thoracic walls.

In latent tuberculosis the patient has every appearance of perfect health, and presents absolutely no physicial signs or symptoms of disease. The frequency of this state of things is shown by the large number of cases, who have died of various diseases, in whom old unsuspected tuberculous foci, revealed post mortem, have been found. Such cases can be detected by means of the x-rays.

In cases of suspected tuberculosis, if the disease attacks the lung suddenly, a fluoroscopic examination shows chiefly a diminution in the clearness of the image at the apex and in the pushing down of the diaphragm on the affected side.

In declared tuberculosis the lesions are plainly shadowed on the screen. In such cases fluoroscopy is more valuable for prognosis than for diagnosis; it will show when both apices are attacked where clinical examination appears to warrant the conclusion that one is still intact, or when the lesions extend lower down than is disclosed by ordinary methods.

In pneumonia there is complete opacity at the part corresponding to the lesion. This opacity, however, varies in its limits and intensity from day to day. The movements of the diaphragm are diminished on the affected side.

Shadows thrown in the first and third stages of pneumonia resemble those of tubercular infiltration. The shadow of the second stage of pneumonia is identical with those of tubercular consolidation.

Non-tuberculous broncho-pneumonic foci causes a slight opacity, but according to Maragliano this becomes less marked on deep inspiration. On the other hand, foci of pulmonary sclerosis, like patches of tuberculous infiltration, do not become clearer on deep inspiration.

In acute or sub-acute bronchitis the two sides of the chest show little or no departure from the normal state, and there is no change in the respiratory movements of the diaphragm—negative signs which may be of importance.

Pneumothorax is characterized by an abnormal trans-

parency on one side of the chest, which allows the light to pass through without any interference, except over a small area on the affected side corresponding to the retracted lung. The heart and vessels may be displaced and the curve of the diaphragm is lower than in health.

In hydro-pneumothorax and pyo-pneumothorax the appearances vary according to the position of the patient; if he is lying down, the whole of the affected side is dark; if he is standing up, the upper side of the part is more transparent than in the normal state, and the lower is opaque.

In emphysema and asthma the reflex is abnormally clear and the movement of the diaphragm is restricted. In simple emphysema the permeability of the lung to the air is increased, and thus the transparency is exaggerated, and the ribs are less distinct. Moreover, the emphysematous lung is larger than natural, and extends into the pleural cul-de-sacs, so that the transparent surface corresponding to the organ extends more upwards towards the mediastinum and particularly more downwards towards the abdomen. When the patient is examined at the back there is seen below the diaphragm a transparent surface of much greater extent than in the normal state.

Circumscribed spots of bright reflex, surrounded by narrow dark shadow rings or located in the midst of an area of dense shadows, indicate cavities.

In cases in which the cavity is single, superficial, empty, and has a thin wall, it shows as a clear zone when compared with the neighboring parts of the lung more deeply shaded; it is oval in shape and sometimes the ribs in part of it are visible.

In cases in which there are multiple cavities the dense intervening tissue is shown in the form of dark streaks winding between the spots of brighter reflex.

A cavity sometimes presents an opaque appearance. Absolute opacity is met with only in the case of cavities full of pus, or when the cavity is deeply seated and surrounded by

pulmonary tissue stuffed with tubercules, or when a covering of dense adhesions prevent the passage of the light rays.

In some cases in which the cavity fills up, the clearness which marks the situation diminishes, and there is only a large shadow, rather deeper at one part than in the rest of its extent. Every degree of variation is possible, but the essential character in all forms of fluoroscopic image of cavities is the presence of a very dark zone more or less annular in outline, encircling a region relatively clear or altogether transparent, while the rest of the lung in the neighborhood is in shadow. It is a sharp contrast between these two elements of the lesion—spots relatively clear showing on a dark ground a shadow fining off at the circumference and sharply cut round the central clear zone—that is characteristic of a cavity.

Old pleuritic adhesions are seen as areas of absolute darkness, even more dense than the normal shadow over the cardiac region. Intense darkness, especially at the lower part of the lung, indicates old pleuritic thickening over consolidated lung tissue. Dense and extensive adhesions of the pleura manifest themselves by shadows less dark but constant in their form. In such a case it is often impossible to distinguish the condition of parenchymatous lesions by fluoroscopic examinations alone.

Pleural effusions are shown in black shadows, the upper level of which may be agitated by succussion, and the fluoroscope shows the displacement of the liquid as the patient assumes various positions and with the motion of the diaphragm. Purulent seem less opaque than serous effusions.

The free movements of the diaphragm are well displayed and are well worthy of study, since it is found that this structure is lowered on the affected side, in cases of consolidation of the apex, and rendered dense and immovable in diaphragmatic pleurisy. The diaphragm descends less and less according to the amount of involvement of the lung, and accordingly would the shadow be denser. There is one peculiar

feature as regards the movement of the diaphragm, and that is the amount of its restriction compared with the lung involved; it seems to be too much out of proportion; and even very slight tubercular changes in the pleura affect the mobility of the diaphragm. In general terms, it may be said that in pulmonary tuberculosis there is a diminution in the movements of ascent and descent in the diaphragm; this change may be observed on one or both sides.

It may be stated as a law that the movement of the diaphragm depends directly on the elasticity of the thoracic contents. The explanation of this is to be found in the fact that when the diaphragm is up, the lungs are small; but when the diaphragm descends, it stops short as soon as it causes the undiseased lung to expand to its limit.

The relative opacity of tubercular glands in the mediastinum has been shown to be less than that of aneurisms. Care must be observed not to mistake the cartilages, trachea, and bronchi for foci of disease.

THE HEART.

The heart may be outlined more accurately than has hitherto been possible. Owing to the fact that the heart is surrounded by the light lung tissue, its movements, as well as displacements and enlargements, can be well seen by means of the fluoroscope. Either uni- or bi-lateral enlargement of the heart and all displacements of that organ can be detected. It is also possible to tell if the heart contracts sufficiently and thoroughly. The pulsations of the heart in a man weighing 150 pounds should show with clearness and distinctness five feet from the tube. The heart of an ordinary man may be seen in nearly normal position and size at between thirty or forty inches distance from the tube.

The heart is sometimes displaced when the position cannot be made out by percussion, and on moving the patient the effusion can be seen to take new position, and by this method

of examination a diagnosis between pleuritic effusion and a thickened pleura can be made. There is no reason to doubt that the effusion of pericarditis would throw a shadow which would be distinguishable from the heart shadow by its greater blackness.

To examine the heart, seat the patient on a stool a couple of feet in front of the tube, with the screen over the heart anteriorly; then sit down and look into the fluoroscope while the patient moves forward or backward until the best view is obtained. A dark room is of course necessary for the best view. As an aid in outlining the size and shape of the heart, hold an ossified aortic ring on the opposite side of the body; this method is invaluable.

In view of the difficulty of measuring the area of the heart upon the anterior thoracic wall by percussion or phonendoscopy, Variot and Chicotot advocate the use of the fluorescent screen. It is easy, they say, to trace with a pencil the fluoroscopic image of the heart on tracing paper fastened to the screen. This, of course, does not give the true size of the organ, but magnifies it; but when one knows the distance between the anode of the Crookes tube and the screen and the distance of the anode from the heart, it is a simple application of the rule of three to correct any given diameter of the fluoroscopic image. The distance of the heart from the anode can be calculated by subtracting the distance of the screen from the heart from the distance of the screen from the anode, and the distance of the screen from the heart has been determined in the case of young children by a series of observations upon cadavers, supported by calculations made on living children confirmed in autopsies. The distance that separates the right and left borders of the heart from the surface of the skin varies with the age of the child; it is about 2.5 centimetres (one inch) at 18 months, 3 c.m. (1.125 inches) at 2½ years, 4 c.m. (1 9-16 inches) at 5 years, and about 5 c.m. (2 inches) from 10 to 12 years.

APPARATUS FOR PRODUCING X-RAYS.

There are three forms of apparatus from which to choose: The Ruhmkorff or induction coil; the Tesla or high frequency coil; and the static machine. To operate an induction coil it is necessary to have either batteries or a current from an electric light circuit supplying direct current. The high frequency, or transformer apparatus, can be operated only from an alternating current circuit. The static machine is the only type of apparatus that does not absolutely require electric current either from a lighting circuit or from batteries. This machine generates its own electricity when the plates are revolved. This is by all means the most simple and convenient manner of producing the x-rays.

Where it is practicable, it is much more desirable and convenient to revolve the plates by means of a motor, for the reason that a greater degree of regularity is obtained; but when there are no conveniences to operate such a motor the x-rays may be successfully produced and results obtained if the machine is operated by hand. If an electric light circuit is available, either alternating or direct, a small motor capable of giving from one-eighth to one-fourth horse power can be employed for operating the machine. In the absence of an electric light circuit a water or gas motor may be brought into service.

Simplicity, convenience and safety in static work stand out in strong contrast with other methods of x-ray generation. During the height of current the operator may safely touch any connecting wire, and with impunity hold the bulb of the glowing tube in his hand; nor does the current need to be switched off every five minutes to cool the tube. When once a demonstration is started it can be continued uninterruptedly to its finish, even though it takes hours; and the features of danger which attend the use of other instruments being eliminated, the operator can devote the attention to his work

necessary to secure maximum results. The manipulation of the machine and tube is extremely simple.

In choosing an x-ray apparatus the physician should always select a static machine, for in addition to its capability of generating x-rays it has a wide range of therapeutic uses. There are but few physicians whose x-ray work alone justifies the expenditure of the cost of an efficient coil, which necessarily when not in use for x-ray purposes is an expensive and useless luxury. Therefore, it is to his own interest, as well as to that of his patients, to utilize an instrument that combines treatment with diagnosis, capable of accomplishing superior work in the x-ray field, and exercising a power to produce a thoroughly efficacious form of medication. It is only the static machine that combines this double usefulness, and, as it approximately costs no more than an efficient apparatus of but single utility, it is evident that it is the best and most economical instrument that a physician can employ.

The static machine and tubes adapted to its maximum discharge will readily and economically equal or surpass the best x-ray effects producible by any or all other means of electrical excitation with any design of tubes that can now be obtained. In brightness of radiance, clearness of detail, and sharpness of definition no method now known, however costly, will surpass the efficiency of a static machine with tubes suited to it. With proper static methods the liability of destroying tubes is reduced almost to zero, and the saving of cost by this fact is a large item.

The use of the static rather than the induced electric current in producing the x-rays is less liable to result harmfully, (*a*) because it is of lower amperage, and (*b*) being of very high potential does not necessitate so short a distance between the tube and the exposed part.

A satisfactory feature in using the static machine is in evidence when using the fluoroscope, as a tube properly manipulated will remain for hours giving off a steady radiance without flickering. No coil apparatus has as yet been so

perfectly balanced as to present this feature in its continuity. This steadiness of fluorescence obtained by the use of the static machine is of great practical advantage in fluoroscopic work, although irregularity in the glow seems to have but little ill effect in radiographic results.

A physician already using static electricity will require but few and inexpensive additions to enable him to carry on x-ray work. In addition to the machine all that is required will be: (*a*) A Crookes tube specially adapted to this form of high potential current; (*b*) a fluoroscope; (*c*) an adjustable stand for the tube; (*d*) plate holder and plates.

CROOKES TUBES.

The Crookes tube, so named from Prof. Wm. Crookes, who studied the phenomena of electrical discharges in tubes whose vacuum were high as compared with Geissler tubes whose vacuum are low, is a closed glass vessel or tube which has been exhausted to a high degree of vacuum, about one-millionth of an ampere—as complete a vacuum as it is possible to obtain.*

In the two ends of the tube are soldered platinum terminals called the external electrodes. The point at which the current enters is *positive* or anode, and the other the *negative* or cathode. Each of the terminals extend into the cavity of the tube, the positive connecting with a square platinum plate and the negative with a round aluminum disc; it is from the latter that the x-rays start. These internal terminals are called internal electrodes. If the internal electrodes are too close to each other, or, on the other hand, are too widely separated, the x-rays emanating from the tube will be of little penetration. The space between them best suited to the

* By a high vacuum is meant that only about a millionth part of the air originally in the tube remains, while in a low vacuum about one-thousandth part may remain. A Crookes tube is an example of high vacuum; an incandescent light of low vacuum.

large Holtz machine is about three inches, with a margin of one-half inch either way, according to the size of the tube.

If the electrodes are in proper relation all the current will be focussed on the anode, and the bulb will appear in twin diagonal hemispheres, one in eclipse (as a dark shadow) and the other luminous (as the sheen of a strong light). The latter is called the hemisphere of x-ray activity ; in the former, practically, no x-rays will be found. These hemispheres of activity and non-activity may be determined either photographically or fluoroscopically, as the "field" may be explored with the fluoroscope and the sharp line of demarkation beween the two "hemispheres" very clearly seen.

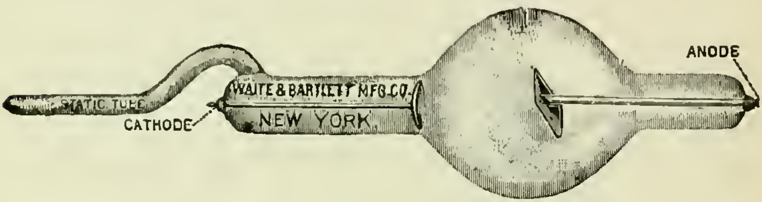

FIG. 18.—SHOWING ONE TYPE OF CROOKES TUBE. The anode (positive) is a square platinum plate. The cathode (negative) is a round aluminum disc.

When a Crookes tube is excited by a proper apparatus, it is filled with a beautiful fluorescence due to the cathode rays, which in turn give rise to the x-rays. There has been a popular misconception that the x-rays proceed from a glass vacuum tube giving a light of dazzling brilliancy ; but such is not the fact, for very frequently a tube may be giving off powerful x-rays and yet be very faintly illuminated. All powerfully excited tubes give off, in addition to the short vibrations producing x-ray light, longer vibrations causing ordinary light. Like the electric current itself, the mysterious x-rays are invisible ; their presence being known only by the effects produced under proper conditions.

Vacuum tubes may vary a great deal from each other even when made by the same manufacturer. Even the very best of tubes do not always possess a reliable, steady and

available degree of vacuum; the vacuum being a constantly changing quantity, can never be relied upon to remain constant. What the correct vacuum should be can not be stated in terms of fractions of an atmosphere, but the demonstration of its degree is as absolute as mathematics.

When the external terminals of a tube are connected directly to the prime conductors of a Holtz machine, a tube of the proper vacuum, as soon as the poles are drawn beyond the sparking distance, will suddenly glow with the proper green luminousity (a bright apple-green color) and the fluoroscope will demonstrate good x-rays; that is, by holding any object, the hand for instance, closely in contact with the outside of the screen it becomes plainly visible.

If the vacuum is very low the electrical discharge will pass in a bluish stream between the internal electrodes, or gather around the electrodes as a thin, light blue vapor with occasionally the appearance of a slight fluorescence on some portion of the glass. In either case no luminosity will glow in the tube. If the vacuum is a little higher the visible blue stream or vapor will disappear, and in proportion as the vacuum rises the green glow will increase in brightness. If the glow in the tube is pink, white or of a decidedly reddish or purple color it is hardly worth while to try to raise the vacuum; also, if a direct arcing stream of electric discharges pass through the electrodes, the tube should be re-exhausted; its vacuum is too low for practical purposes. When a tube shows a dull green color and bright green flakes of light from the cathode (the round aluminum disc), and along the bulb toward the middle of the tube, it is an indication of the vacuum being too high.

If the vacumn in a tube has become too high, electrical discharges will not pass through the tube, and it will remain dark and little or no fluorescence of the glass will appear. Sometimes when the vacuum is too high sparks will pass from terminal to terminal outside of the tube.

In a tube of very high vacuum the current may back up

(when a discharge refuses to pass through a tube it is said to "back up a spark," which may be two, four, or more inches between the terminals), and leak from the connecting wires without going through the tube, the tube remaining dark or occasionally a flicker passing through it; or in some instances there will be observed a continuous succession of bright fluorescent flashes along the glass.

It is well known to those who have made extensive use of Crookes tubes in x-ray work, that, after some time, the vacuum will rise so high that the electrical discharge from the exciting apparatus cannot be forced through the tube. The fluorescent and the x-ray effects will cease and usually, the inside of the tube will have a blackened and dirty appearance.*

If the tube is cracked or punctured it will be filled with a *dark blue* or purple cloud or the spark will jump from one electrode to another inside the tube. Such a tube will be useless.

The green serpentine movement seen within a Crookes tube when charged with a coil machine indicates either that the tube is worn out or that the voltage is too low; if with an influence machine, it indicates wrong connection to the tube.

Roentgen suggests that a low vacuum tube, one which does not emit highly penetrating rays, be called a "soft" tube; and a tube in which the exhaustion has been pushed to an extreme degree, one in which highly penetrating rays predominate, "hard" tube.

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*It is claimed that this dirty blackened appearance of the tube is due to the disintegration of the platinum electrode and the depositing of the particles on the wall of the tube. These particles are driven off under the influence of the electrical discharge and, upon cooling, they absorb or condense gradually what little residual gas is left in the tube, thus creating almost an absolute vacuum and the tube becomes useless for the generation of x-rays as an electrical discharge will not pass freely in a vacuum. When the outside of such a tube is heated the particles of platinum will throw out the air they have absorbed and the tube may then "come to life" or be ready for work again.

If the vacuum in an x-ray tube is either too high or too low, results will be unsatisfactory.

TO RAISE THE VACUUM.

If the vacuum in the tube is too low for good x-ray work, it must be raised electrically. To do this the first and most simple method is to reverse the polarity—that is connect the positive terminal of the tube to the negative pole of the battery, and the negative terminal of the tube to the positive pole of the battery. Let the current continue to pass through until the tube shows in a satisfactory manner the phenomena peculiar to reversal.* Then stop the machine, disconnect and turn the tube around to its normal position, and the chances are that the tube will give good x-rays.

Under some conditions of the tube, when the vacuum is too low, the use of the small Leyden jars will improve the glow. In the employment of the Leyden jars Monell advises the following method: Remove the wire from the prime conductors, attach them to the connections for Leyden jar currents, and place the smallest jar in position. Short circuit the poles. The jar from the positive prime conductor is negative and the direct polarity is reversed. Remember this. Connecting the tube cathode terminal to the positive Leyden jar, start the machine into rapid action and draw the poles apart until the spark stream splits and the glow in the tube begins to oscillate. Continue the discharge through the tube for about five minutes. During this treatment the poles will vary with different tubes from four to eight inches apart according to the condition of the machine and state of vacuum. Next stop the machine and reverse the current polarity, short

* A tube in reversal will present a green striæ, with very faint nebula, together almost filling the tube; or the cathodal end, including one-third of the tube, is bound with a distinct zone with lighter right angle radiations. Luminous spots of a bead or bug-like appearance may often be seen in varying positions clinging to the inner surface of the tube.

circuit the sliding rods, start the current, and when the plates revolve as rapidly as safety to the apparatus permits draw the poles apart until the glow wavers. Use the hand over the fluoroscope as a familiar test, and adjust the distance between the poles until the bones appear brightest and the image steady. If the lines are somewhat dark the vacuum is still lower than it should be. Keep the spark stream in action for five or ten minutes, and if the tube is worth coaxing at all it should now produce x-rays of fair efficiency.

In many instances a tube of moderately low vacuum can be "worked up" gradually to do good x-ray service. After the tube has been properly connected start the machine into action and draw the poles apart, then watch the appearance in the tube. The blue stream or vapor should soon give way to the characteristic green color denoting good x-rays. The current must not be too strong. Watch the electrodes to see that they do not become too hot.* If they become of a white heat reduce the current or stop it for a few moments then resume again. Several trials of this kind, if necessary, should bring the tube up to a proper fluorescence. It will often require ten, fifteen or thirty minutes or even longer to bring such a tube up to do efficient x-ray work, but with care and persistence this can finally be accomplished. An interrupter or spark gap may be inserted at the positive pole or anode. It increases the efficiency of action of the tube, and x-rays may often be derived from a given tube at a lower vacuum when a spark gap is in the circuit than would be possible without it.

It is the experience of practice that a tube of low vacuum is by use raised to a higher vacuum, the resistance of which will, sooner or later, be almost, if not entirely, impossible to

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* In the low vacuum tube the heating of electrodes to a white heat is to be avoided, as is overheating of the glass; both lower the vacuum still more.

The platinum reflector in a tube glowed with a coil is generally heated a cherry red, while it may be run consecutively day and night with the static machine and a proper current, without producing this redness at all.

overcome. Then we have reached the most difficult and troublesome point of x-ray work—how to lower the vacuum.

TO LOWER THE VACUUM.

One of the most practical matters which can concern the operator in x-ray work is the question of getting a current through the tube when the resistance has become too high. So far no tube has been constructed whose vacuum is constant. The state within the tube fluctuates from day to day, until, from more or less usage, a tube which in the beginning gave off good rays will, in course of time, offer so much resistance that the discharge will no longer readily pass through, and by persisting in the use of the tube the resistance becomes so great that by every known means of "coaxing" it is no longer possible to overcome it.

The methods employed for overcoming high resistance are: (*a*) application of heat from an alcohol lamp or a Bunsen burner; (*b*) baking the tube; (*c*) boiling tube in oil; (*d*) setting the tube aside for rest; (*e*) application of tin-foil; (*f*) reversal of polarity; (*g*) the employment of current interrupters; (*h*) re-exhaustion.

Application of Heat.—When a good tube with a high vacuum has been used for some time, it will often be noticed that it requires a greater potential to get the proper fluorescence, and that the vacuum has become so high that the tube will not fluoresce; if then the tube be warmed gently by a spirit lamp, applying the flame to the surface momentarily, the particles of air which have taken refuge in the glass of the tube are liberated, the vacuum is reduced, and the fluorescence returns. This must be done boldly and yet carefully. The flame should be passed along the bottom of the tube, never resting in one place, until at last the entire tube has become evenly hot; then the lamp is withdrawn to a distance and the current turned on. If the sparks still fly around the inside of tube the heating must be continued. In using a

spirit lamp one precaution must be kept in mind: The alcohol will be ignited if it is brought near to the tube while the current is passing and an explosion may occur. Hence, the advisability of employing a Bunsen burner.

Baking the Tube.—Wrap the tube in cloth, place it in a hot oven for from one to two minutes; or hold it over a hot stove and keep turning the tube until it becomes gradually quite hot; or place it upon a shelf above a range for fifteen or twenty minutes. After trying any one of these methods allow the tube to rest for several days. These methods will sometimes give a new lease of life to a tube. This after all is but a temporary experiment and is only successfully applicable a limited number of times. With each time of heating the subsequent usefulness of the tube becomes less and less, until no further work can be obtained from it.

Boiling Tube in Oil.—It is often the case that by boiling a tube in oil its efficiency is temporarily restored.

Resting Tube.—If, however, coaxing fails for the time being, set the tube aside to rest a few days and meanwhile use another tube. When the rested tube is again tried it will sometimes be as good as new.

Application of Tin-foil.—The application of tin-foil to the negative terminal of the tube, beginning about one-half inch from the wire and extending over the arm of the tube until it begins to expand into the central bulb, will often assist in overcoming high resistance in a tube when all other methods have failed. To Dr. Wm. W. Graves, more than any other experimenter, belongs the credit of developing this method for overcoming high resistance in a tube. On this point he says as follows: "Early in January, 1898, one of my tubes died—that is to say, after trying every accessible method save rest, baking and boiling, the discharge could not be gotten through. While the machine was in full operation a piece of tin-foil, which I held in my hand, fell upon the tube in such a manner as to form a bridge within one-half inch of cathode terminal wire to a point on bulb about midway between cathode

and anode. Immediately the tube glowed with brilliant radiance. On removing the foil, the glow died out; on replacing it, the glow returned. I noticed at the time that a fine brush discharge, intermingled with a few sparks, was taking place between the cathode terminal wire and the foil, and that the other end, in contact with bulb, fine, forked, radiating discharges were taking place, spreading over the bulb in every direction from margin to foil, the discharges being thicker at the margin, growing thinner a short distance away, and finally disappearing." Again he says: "On interrupting the negative discharge at cathode terminal wire with the foil, as well as at the pole of the machine with the interrupters, the negative discharge is seemingly intensified, so that internal resistance may be overcome which could not be overcome by interrupting the discharge at either point alone. A spark-gap, a brush discharge, either or neither, may be readily had between cathode terminal wire and foil, by shifting the position of the foil up or down, and by varying the length of spark-gap at negative pole. The effect on the tube resistance is greater with the spark-gap between foil and terminal wire, and less with brush discharge, the wire having no effect when neither is passing—that is, when the foil is in direct contact with terminal wire." He advises that a strip of tin-foil of several thickness be glued to the arm and bulb of the tube, thus avoiding all possibility of puncture by close contact of tin-foil to the tube.

Reversal of Polarity.—Reversal is one of the chief essentials for success. The discharge should be made to pass through the reversed manner until the glow is constant, and until the arrangement of striæ in anode end of bulb of ordinary resistance reversed, particularly until those spots which may often be seen in varying positions in bulb are driven back and are absorbed, so to speak, by the striæ from which they may have originated. When these spots have been driven back, disappear and become a part of a normal arrangement of striæ, when the glow has become constant, when in

a tube of advanced development it shows steady radiance, as may be demonstrated by the fluoroscope, the proper degree of reversal has been obtained. Interrupting the discharge at the positive pole will assist the reversal connection in reducing the resistance. If the tube then be properly connected, it will usually glow; but if it does not, by interrupting the discharge at the negative pole with an interrupter the tube will then, as a rule, immediately glow with brilliant radiance.

Current Interrupters.—Current interrupters are extremely useful devices, whether for a tube of *low* or one of *high* vacuum. They are, however, of special value in tubes of high resistance. In fact, if properly employed, they will contribute more to success in overcoming high resistance than any other one method, and will make a tube of moderate efficiency do good work more quickly and with less trouble than by any other means.

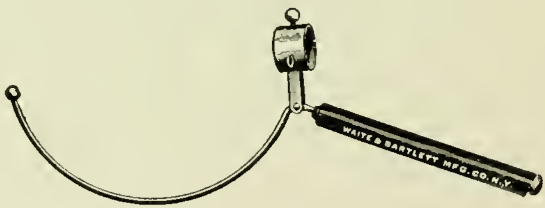

Fig. 19.—Showing One Type of Current Interrupter or Regulator. There are two of these, and as their name implies, their purpose is to regulate the light within the tube. Place them on the handles of the sliding pole rods and fasten firmly by the round top screw. The length of the spark in relation to the light in the tube being governed by the distance of the balls on their curved arms from the large ones on the sliding poles. The spark distances are regulated by the movement (up or down as the case may be) of their handles. The milled screw on the arm that connects the curved rod to ring is used for tightening the joint when it works too loosely.

Of the value of current interrupters, Graves says: "I have observed a difference in effect produced on tube resistance by the interrupting of either the positive or negative. In any case, if the resistance is satisfactory the interrupters should not be used. Either one, or both, should be used for a

specific purpose, for under certain conditions, by using the one or the other, resistance may be increased or diminished. In a tube of low resistance the use of either, or both, will seemingly increase its efficiency. In a tube of ordinary resistance, that is to say, one which will back up a spark-gap of from one to two inches, interrupting the discharge at positive pole appears to increase the efficiency of the tube more than by interrupting the discharge at the negative pole. In a tube the resistance of which has become so great from usage that the discharge will no longer readily overcome it, only the interrupter at the negative pole should be employed. In my experimental work, I have observed repeatedly that if the interrupter at the positive pole be employed, resistance will increase rapidly, so that the discharge will not pass through; whereas, if the interrupter at the negative pole is employed resistance is seemingly lessened and the tube will often glow."

The following rule, as regards the employment of current interrupters, must be borne in mind: If the current is interrupted on the negative side the vacuum of the tube is lowered, while if the current is interrupted at the positive pole the vacuum of the tube is increased. Or, in other words, in a tube of high resistance only the *negative* interrupter is to be employed, while in a tube of low resistance, only the *positive* interrupter is to be used.

Re-exhaustion.—If a tube raises so high in vacuum that no discharge can be sent through it, then the only thing to do is to send it to the manufacturer to be re-exhausted. As a rule, it is not good economy to send a tube back for repairs, for the life of a repaired tube is usually of a few days and full of trouble, and it will certainly break down just at the time when it is most needed. The better way is to learn the best method of prolonging its usefulness, and when that is over discard the tube entirely.

The Crookes tube will give the best service if wholly free from the entangling devices sold under the name of self-regulating tubes; in fact, there is no such thing as a self-regulating

tube in the sense of regulating vacuum; the vacuum is probably not altered by use, and the change that takes place in the tube is a rearrangement and possibly displacement of the contents of the tube. In using a new vacuum tube, it is usually better not to employ the maximum current upon first trial, but bring the tube up to its full capacity gradually. Many a tube is spoiled by discharging through it when it is first used the full capacity of the coil or machine. Frequently a new tube will show a very light blue cloudiness around the electrodes, and this should be worked out gradually by first operating the tube only with a small current.

Given a powerful Holtz machine and the best fluoroscope, x-radiance beyond the ordinary depends upon the tube and the operator's skill. A high-efficiency Crookes tube is therefore the most essential factor in the maximum surgical utilization of x-rays. It is an instrument of extreme delicacy and of a variable nature. To deserve the term high efficiency the selected tube must readily and profusely produce x-rays of constant and steady action which will penetrate powerfully to a considerable distance and give sharp detail and definition to shadows. Such a tube requires a high vacuum, for x-rays generated in high vacuua have more penetrative power than when the vacuum is less high.

It now appears instead of a tube losing its efficiency from use it actually gains in penetrating power the longer it is used in the proper manner. Proper manipulation of the tube rearranges and adjusts the elements in such a way that former efficiency returns and even greater penetrating power is obtained. Heating, resting, re-exhaustion, etc., are simply temporary expedients, and in no way improve the former condition, but rather diminish its former penetration and endurance.

Now, if it is a fact, and experience so teaches that the greater the resistance as afforded by the vacuum tube the higher will be its efficiency when the resistance is overcome, it must follow that approaching maximum radiance will not

be attained until it is possible to overcome all resistance. Therefore those tubes that are set aside for rest, and those that are returned to the makers for re-exhaustion, are the very tubes, which, if their resistance can be successfully overcome, are capable of affording nearest approach to maximum radiance.

A tube should have a constant glow. Constancy is the ideal condition, and is observed when the full output of a machine is passing through a tube which silently glows, noiselessly as an incandescent lamp. If the radiance is fluctuating and not constant an examination can not be satisfactorily made. The raising and falling of penetrating rays cast movable clouds across the screen and in a degree, change the aspect of the subject under examination into a doubtful diagnosis.

Whether for fluoroscopic or radioscopic work, approaching maximum radiance is always to be desired. A tube which only gives fair radiance has little practical value, other than from development by usage it may attain high efficiency.

It is claimed that the best way to work a tube at its highest state of efficiency is to operate it intermittently in a high state of activity. A most vivid x-ray (as represented by the fluoroscope) occurs when the platinum reflector in the tube is at a red or white heat, but there is danger in heating the reflector to this degree, except at brief intervals, of lowering the vacuum in the tube.

A high efficiency tube should glow promptly upon starting the machine into action, and maintain an even and brilliant radiance during a reasonable length of time, or be caused to do so by such reasonably brief manipulation, as nearly every tube in frequent use requires. It must be kept in mind that a vacuum tube in perfect condition is useless if the coil or static machine upon which it depends is out of order, and that the most perfect generator of current will not produce satisfactory x-ray effects from a tube in which the vacuum is too high or too low.

METHODS OF OPERATING A TUBE.

The three best methods of operating a tube with static machines are: (1) By direct connection to the prime conductors; (2) the interposition of current interrupters in the direct current; (3) Leyden-jar connection.

Direct Method.—Sometimes one method will prove to be best with a given tube, sometimes another; but the ideal method is the direct, when nothing save the whirl of the plates can be heard and the glow in the tube is as steady as that of an incandescent lamp. In this method the tube is connected directly to the poles of the battery. It is claimed that by connecting the largest of the Leyden-jars to the prime conductors, their outer coating not being connected, the current is thereby reinforced. Start the machine into rapid action and observe the tube with the fluoroscope. If the interrupters are attached, be careful that the jar of the machine does not separate their balls from those of the prime conductors. Should this occur the glow in the tube may suddenly cease and the efficiency of the x-rays be diminished or entirely lost.

Direct Method with Interrupters.—In this method the wires from the tube are attached to the eyelets in the interrupters instead of being attached directly to the poles or prime conductors of the machine. There are two of these interrupters, one secured upon each of the handles of the sliding poles of the machine. Each interrupter should be adjusted so that the metallic ball is at first in actual contact with the outer brass ball of each prime conductor. Start the machine (the sliding poles being separated sufficiently to prevent the sparks from jumping across) into rapid action and observe the tube with the fluoroscope. (The light on the screen of the fluoroscope increases or diminishes, according to the movements of the interrupters.) If then good x-rays do not develop, slowly separate the ball on the interrupter (the

negative in case the tube is one of high vacuum or the positive if the tube is of low vacuum) from that of the prime conductor until the spark-gap is at the point which produces the best x-rays—varying from one-quarter to an inch or more in case of different tubes. The length of the spark-gap must be regulated to suit the vacuum in the tube. When the vacuum is low the gap must be long, while with a high tube the gap must be shorter. The point at which all tubes, whether high or low vacuum, give the best results, is when the gap is shortened just enough to prevent flickering in the tube. In some instances better effects will be obtained by employing both interrupters at the same time; but this will be of rare occurrence.

Leyden-Jar Method.—Attach a pair of Leyden-jars to the prime conductors, the same as for the static induced current. To the outer terminals of these jars the wires from the tube are to be attached. A point that must be remembered is that the jar from the positive prime conductor is negative and that from negative prime conductor is positive. The explanation of this fact is, that when the positive prime conductor of the machine is connected to the internal armature of one Leyden-jar it will induce a negative in the external armature of the jar; this then becomes a negative pole. The external armature of the other jar receives a positive charge and is therefore the positive pole. The size of the Leyden-jar employed will be governed, more or less, by the degree of vacuum in the Crookes tube. The higher the vacuum the larger must be the Leyden-jars. As a rule, it will be found that the small jars are all-sufficient; besides there is great danger that the discharge from large Leyden-jars will crack the glass of the Crookes tube. When all connections have been accurately made, start the machine into rapid action and gradually separate the sliding poles (4, 5, or 6 inches) until the tube glows with a steady radiance, as determined by the fluoroscope. Care must be observed that the poles are not separated too widely, for in that case the image would oscil-

late. Sometimes a tube that has worked well for a while on the primary poles will refuse to work well longer; then by connecting it with the induced current, it will as a rule work again.

PREPARING X-RAY APPARATUS FOR WORK.

The operator had best be provided with a stand or holder for his Crookes tube. An adjustable stand, that will enable the operator to place the tube in almost any position, is the best for the purpose. The tube will be more safely and firmly held if its elongated externum is provided with a cube of cork perforated in such a manner that the extension of the tube will pass tightly through the hole. The cork can be then conveniently grasped by the clasping arms on the stand.

The wires (two in number) which are used to connect the tube to the machine should be well insulated, and from four to six feet in length. If long wires are used it is well to have them supported by proper stands. Care must be taken that they do not touch the tube, for fear of the electrical discharges perforating the glass; also that these wires do not come too near each other or the poles of the machine. The wire must not be too fine, for in that case they sway too easily and leak off the current when the attraction of opposite polarities bring them near together; nor must they be very large, for if large wires are used to connect to the tube terminals there is danger of cracking the glass. No. 20 is a good size for all-round work.

Before making connections always test the polarity of the machine (for tests of polarity see the method of so-doing in first chapter on "Static Electricity"). The tube is then fastened in the adjustable stand and the conducting wires (both ends of each wire having been exposed) loosely hooked in the ring at either end of the tube, the other ends of the wires at some point on the machine indicated, either the sliding rods or the eyelets on the interrupters.

The *positive* (anode) end of the tube (the end containing the square platinum plate) must always be connected with the *positive* pole of the battery, and the *negative* (cathode) end of the tube (the end containing the round aluminum disc) with the *negative* pole of the battery.

Turn the tube so that the platinum reflector (the square platinum plate) presents toward the eye when the operator stands in front of it, that is, when employing the fluoroscope; but when making a radiograph turn the tube so that the rays from the platinum plate (anode) fall directly on to the spot to be photographed.

All connections having been properly made, separate the sliding poles sufficiently to prevent the sparks from jumping across; then start the machine and run it as fast as possible with safety to the plates. Watch the tube with the fluoroscope. If x-rays are being generated, the fact can be demonstrated by holding the hand between the fluoroscope and the tube. If the screen of the fluoroscope shows no light it is an indication that the tube is connected wrong. To change the connections of the tube, either stop the machine or push in its sliding poles so that they touch each other. When the change is made, pull them apart and proceed as before. Never run the tube "backward;" that is, with wrong pole connection, for it raises the vacuum rapidly and few rays are given off.

RADIOGRAPHY.

Various names have been given to the pictures taken by the x-rays and to the method of so taking them, such as radiograph, skiagraph, Roentgengraph, cathograph, etc., but the terms radiograph and skiagraph are now employed almost entirely when speaking of an x-ray photograph.

A picture of any object obtained by means of the x-rays is not, strictly speaking, a photograph, for in photography lenses are used, by means of which the object photographed is

focussed on a sensitized plate on a smaller or greater scale, while an x-ray picture of any object (or "radiograph," as it is generally termed) cannot be made any larger or smaller than the object, because lenses cannot be employed to condense the rays (as the x-rays pass straight through the lenses and can neither be reflected nor refracted); therefore, a radiograph is practically a life-size *shadow picture* of the object. A radiograph, however, can be photographed in the ordinary way, and thus a new picture of the object, increased or diminished in size, obtained. Photo-fluoroscopy is the name given to the process of photographing objects thrown upon a fluorescent screen.

It must be remembered that all x-ray pictures, whether taken radiographically or seen only on the luminous screen of a fluoroscope, are not pictures of *surfaces*, but are, in reality, *shadow* pictures.

All x-ray shadows are distorted. There is a normal divergence of the x-rays. The divergence of the x-rays equal, in all conditions, in every sixteen inches, $\frac{13}{16}$ of an inch. This divergence is perpetual, constant and never varies. It is the same from all tubes under all conditions. The radiograph is a shadow cast by rays emanating from a point. The bundle of rays which project this shadow is, therefore, made up of rectilinear divergent rays, and the shadow must, consequently, be larger than the object. Not only is this true, but the parts lying at a greater distance from a point where the rays strike perpendicularly are more distorted. There is also distortion due to position; this may sometimes, possibly, be avoided, but rarely, unless impervious right angle devices are used to correct it. In both instances the distortion can be corrected with mathematical accuracy by means of a fluorometer.*

* Recently Morgan has devised three simple methods of localization, any of which will give accurate results. The first method is as follows: Suppose one desires to locate a bullet in the hand, a piece of copper wire is bent around the hand at or near the supposed location of the missile. On ex-

The size and shape of the shadow of each part will depend upon the relations of the distance between the point of light, the part of the object, and the plate. Thus the distance between the light and the plate remaining the same, the farther an object is from the plate the larger will be the shadow; and the farther an object, or part of an object, from the base of a perpendicular from the point of light to the plane of the plates, the more will its shadow be distorted, the distortion being due to elongation in the direction of a line from the

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posure of the part to the rays the wire will assume an elliptical or fusiform shape (according to its obliquity to the reflecting platinum surface in the tube), or when the center of the anode-reflector, the distal and proximal surfaces of the wire, and the shadow of the screen are all in line, the wire will seem to be a single, straight piece stretched across the hand. The latter appearance is what is desired, and one should now move the wire bracelet upward or downward until it looks as if the piece of straight wire passes directly across the bullet. The location of the wire should now be carefully marked upon the skin. The bullet must necessarily be found directly between these lines. Its relation to the radio-ulnar surfaces will be found by looking in an antero-posterior direction, and its depth in relation to dorso-palmar surfaces must be determined by like examination from side to side. The same principles have been employed by adjusting two key rings to rubber bands and placing the rings upon the opposite surfaces of the part to be examined. When the two rings appear as one ring and the foreign body lies in the center, the localization from that direction is as definite as a mathematical problem. To make any localization complete, views should always be taken in two or more directions, and the conditions and positions of everything involved in the examination be thoroughly known and appreciated by the surgeon. In the third method take four pieces of copper wire of equal length, solder the ends of three of these together in such a way as to form a three-limbed base, each limb projecting at an angle of 120 degrees from the center. To the center of this base solder the fourth wire at right angle to the other; that is, with the base lying on the table, the center wire projects directly upward. This little instrument is termed a "jack." In an examination for locating a foreign body the jack is to be held on the distal side of the part under examination, with the base out or away from the part and the upright or center wire pointing towards the foreign body. When it points in this direction, and the fluoroscope is on the same level it will be covered by the foreign body, and only the three base limbs of the jack will be seen, whereas if the jack is not properly placed, all four of its arms will be visible. All of these methods are of the same elementary kind, and yet are capable of giving as good results as are to be attained by the more elaborate and expensive instruments.

base of the perpendicular through the object. When the object is at the same time away from the plate and away from the base of the perpendicular, both of these distortions will take place. Further, since each object or part of an object contains only a certain amount of shadow-casting material, the further it is from the plate, the greater will be the size and the less the density of the shadow.

The further the tube is placed from the object radiographed the less distortion will there be produced, as the rays will be more nearly parallel. If the tube held close to the part exposed, or the part exposed is held away from the plate, the resulting radiograph will be magnified and distorted.

The distance from the plate to the tube should be as great as possible, and from the object to the plate as short as possible. The distance, therefore, must be gauged by the intensity of the rays and convenient time of exposure. If the object is too near, the diverging rays give a tendency to distort the image, whereas if the distance is too great, the efficiency of rays may be lost. One of the advantages of a high-efficiency tube is that the object may be examined at a greater distance, thus giving better definitions.

Place the tube at such a distance from the plate that the shadows from the subject are not too divergent. The shadow picture should be as nearly life-size as possible to get sharply definite outlines. Therefore, in taking radiographs of thick objects the tube should be some distance from the plate, even if it does require more time of exposure.

The wider the object the greater must be the distance between the plate and the tube. For instance, a radiograph of the hand at ten inches is very little distorted, because the x-ray would strike the outer fingers at more acute angles.

The deeper the object the greater must be the distance between the plate and the tube. A knee at ten inches, though little wider than the hand, would yet be considerably distorted, for it is so thick that the parts farthest from the plate

would be much enlarged; the external condyle of the femur (the plate being in the inner side, for instance,) would appear much larger than the internal.

In radiographing the femur, if the plate be on the anterior side and the tube very near the posterior, the shadow of the femur will be broadened and diminished in density, so that the shadow of the patella, which is but little magnified and as dense as before, will be seen through it.

In taking radiographs we must always know the power of our x-ray, the distance of the tube from our objects, the distance from the plate, the duration of the exposure, and the angle at which the picture is taken.

To read correctly the lesson of an x-ray picture, keep the obliqueness of the x-rays always in mind, make it as nearly life-size as possible to get sharply defined outlines, remembering that we are dealing with shadows only, and use a proper dividing screen for measurements and exactness of your pictures.

The strength of the x-ray decreases as the square of the distance increases, so it will take just nine times as long to take a picture at fifteen inches from the tube as at five, because fifteen is three times five and the square of three is nine.

The length of time of exposure and the distance at which the object is to be placed frcm the tube varies with different tubes, and with the same tube at different times, and can only be learned by practice.

It should be remembered that the greater the distance from the tube the clearer the definition, although the exposure must be longer.

In actual practice the operator must not measure his work by any given length of exposure, but rather must judge of it by aid of his experience with the fluoroscope; he must become so accustomed to the use of the fluoroscope that gradually the relation of exposure time to the state of the tube will be familiarly and accurately known. If the glow is fine and constant, the exposure may be short. If it is ten, fifteen or

twenty per cent. below par, the exposure must compensate in time what it lacks in intensity. The distance from the plate to the tube may easily be ten or twenty inches with a good tube, or must be reduced by half if the rays are feeble. With the best tube two feet is no more than six inches with an inferior tube as regards exposure time.

The following table as to time of exposure and distance of objects from tube is given only as an approximate standard to serve as a guide. A very short experience and practical use of the x-rays will soon enable the operator to decide upon the necessary time of exposure and distance of object from tube to obtain the best effects. Objects of small size will, of course, require a very much shorter time of exposure than large or dense objects, although, in any event, the time of exposure increases with the distance of the tube from the object:

	Time of exposure.	*Distance of plate from tube.*
Hand and wrist,	30 to 40 seconds.	15 inches.
Arm,	1 " 2 minutes.	15 "
Elbow-joint,	2 " 3 "	15 "
Shoulder,	3 " 5 "	15 "
Thorax,	8 " 12 "	20 "
Pelvis, footnote,	8 " 15 "	20 "
Hip-joint,	8 " 15 "	20 "
Knee,	2 " 5 "	15 "
Leg,	2 " 5 "	15 "
Foot,	2 " 5 "	15 "
Glass, lead, iron in any part of the trunk,	2 " 5 "	15 to 20 "

For a full and satisfactory picture of the trunk of the body, showing all the osseous detail, five to eight minutes should be allowed, with the sensitive plate 20 or 25 inches from the reflector.

When employing a large ten or twelve plate Holtz machine, the time of exposure for thorax, pelvis or hip will rarely exceed four or five minutes, and it is not necessary to place the plate closer than 20 or 25 inches.

Caution as to having absolutely *no motion* of the subject on the plate is best obtained by strapping the patient down, or

fastening the part to the plate, so that no exaggerated or distorted photograph can result. It should be borne in mind that objects may be tied down to the plate-holder by means of thread, twine or even fastened with rubber bands, and yet not shown in the radiograph, as the x-rays pass entirely through them and leave no shadow of them upon the plate.

A radiograph can be taken irrespective of a light or dark room. It is better, however, to have the room darkened, more or less, so that the operator can carefully watch the tube through the fluoroscope, so as to be certain of its action. Before taking a radiograph the efficiency of the working power of the tube should be tested with a fluoroscope; also during the exposure the action of the tube should be observed.

The location of foreign bodies in the extremities is never difficult to radiograph; clear, distinct pictures being uniformly obtained. The location of foreign bodies in the head, lumbar vertebra and upper sacral region is more difficult, and, as a rule, requires more than one exposure. It is essential in all cases where tissues, other than the arms and legs, are to be examined, particularly in the trunk and the head for bullets, that radiographic and fluoroscopic observations should be taken from two or more points of view, at right angles to each other.

In order to make a correct diagnosis and to produce an accurate picture, we must never be satisfied with one radiograph of the case, but make it also our duty to compare the picture of the injured part with the natural one.

The radiograph, in some instances, has an advantage over the picture seen by the eye upon the screen. Certain parts, such as the sternum and ribs, appear as simple shadows on the screen, whereas the radiograph often brings out fractures and numerous other details.

In many cases of minor surgery a fluoroscopic examination is all that is necessary before making an operation; but in major operations a fixed and permanent record upon a sensitive plate is of much higher value; for a good radiograph is

of greater value than the momentary appearance of a shadow cast upon a screen. To secure a radiograph, or even more than one, requires but little more time than a careful fluoroscopic examination.

A radiograph, if proper light and exposure is had, should show the different layers of clothing, the skin, the fat, the muscles, the bones, and bones through bones, the marrow and cancellated bone structure, and in certain poses the blood vessels, intermuscular spaces, the shading of the muscles, depending upon their densities, and tendons and their attachments.

FLUOROSCOPY.

When Mr. Edison took up x-ray work, and developed a practical devise which he has named the *fluoroscope*, he contributed to art one of the greatest aids. The fluoroscope owes its existence to the fact that certain crystalline chemical salts possess the peculiar property of exhibiting fluorescence when brought within the sphere or influence of the x-rays. There are several chemical salts that possess this peculiarity, but only two kinds have up to this time been found most generally useful; they are platino-cyanide of barium and tungstate of calcium.

The fluoroscope is simply a box, somewhat similar to the stereoscope, the front of the apparatus being covered on the inner side with tungstate of calcium or barium-platino-cyanide, and when the x-rays impinge upon the particles of this coating they become visible to the eye. As the x-rays are absorbed to a different degree by the various structures of the body, the fluoroscope enables us to note these effects with the eye*.

The fluoroscopic screen should never be permitted to re-

* It has been computed that one person in every 800 is blind to the x-rays. That is to say, when looking through the fluoroscope, they are utterly unable to observe the bones of the body, coins, or any other object which is clearly distinguishable by the ordinary observer.

ceive the least particle of dust. It is on this surface that our knowledge is gathered. Dust will distort, shade, and otherwise injure the shadow. Shadow has no thickness and every particle of foreign matter upon the fluorescent material will to that degree injure the picture.

In using the fluoroscope, the object to be examined is held between the instrument and the Crookes tube. The x-rays will project a shadow of the object upon the coated surface of the fluoroscope, and the invisible x-rays, being transformed through the fluorescent properties of the tungstate of calcium or barium-platino-cyanide into luminous rays, the shadow of the object becomes visible.

FIG. 20.—FLUOROSCOPE, WITH BARIUM PLATINO-CYANIDE SCREEN.

In examining an object with the fluoroscope, it is not the object itself that is seen but only its *shadow* cast upon the screen. When the object is close to the screen the shadow is life size and most clearly defined, while if removed to some distance from the screen, the shadow is increased in size and loses in distinctness.

The solid viscera throw a shadow upon the fluoroscope whose intensity depends upon the density and thickness of the viscus or organ. The shadow thrown upon the fluoroscope of a solid viscus situated in the posterior part of the

body is darker in the center of the shadow and lighter around the margin.

Viscera, consisting of one or more cavities containing gas give a brighter projection upon the fluoroscope if the tension of the gas is great; also in a hollow viscus containing both gas and fluid, the part containing gas will throw a light shadow upon the fluoroscope, the part containing fluid, a dark shadow.

If a viscus of a certain thickness and density lies deeply behind another of the same density, their shadows will be superinforced upon the fluoroscope and the result will be a single dark shadow.

A solid viscus, or a viscus filled with fluid, situated behind a hollow viscus, will throw a lighter shadow upon the fluoroscope in proportion to the thickness of the hollow viscus.

If the wall of a hollow viscus be thickened at any point the shadow of the viscus will be less intense at the thickened point, for at this point the layer of air will be less deep or even absent altogether.

Osseous structures throw a very dark shadow upon the fluoroscope. The shadows which any part of the body containing bone throws upon the fluoroscope consists of a shadow of the bone plus the shadow of any organ lying behind the bone. The shadow thrown upon the fluoroscope by an organ enclosed in a bony cavity is entirely obscured by the darker shadow of the bone.

The movements of various viscera, whether physiologically or artificially produced, can be distinctly seen in the fluoroscope by the motion of their shadows, provided, of course, that the tube and fluoroscope remain stationary.

In order to make the x-ray shadows in the fluoroscope clear and distinct the instrument must be applied closely to the body at the point at which the organ to be examined is most superficial.

In using the x-rays it is best to place the tube opposite the viscus to be examined and the fluoroscope directly over it, or

if the viscus be a large one the fluoroscope must be placed upon several different parts of its surface.

The proper distance between the tube and the fluoroscope is easily acquired. No sure rule can be laid down as to how close it is necessary to bring the fluoroscope to the tube which is being excited. Where a tube is generating a great abundance of x-rays, it will not require as close an application as with one of low power. Ordinarily the observation is made within one or two feet from the tube. The exact distance, however, is regulated by the operator's judgment. In making a fluoroscopic examination the fluoroscope is held in the right hand, the eyes are deeply placed within the opening to exclude all light, and the screen is held in close contact with the hand, limb, body or object to be examined. If the screen is not in contact with the object the shadow of the object will be magnified or distorted. The screen can be moved over an extensive part until the limb or body is examined, by always keeping the portion of immediate interest nearest the tube.

In making accurate fluoroscopic examinations a great deal depends upon the intensity and steadiness of the light; also considerable practice is necessary before the eye can appreciate perfectly the finer differences of shades and outlines.

While fluoroscopic examinations can be made in a light room, yet, as a rule, it is better to have the room partially or wholly darkened, for when the fluoroscope is used in a light room and the operator removes it from the eye it takes several moments on renewing the operation to get the eye back to the proper condition for making accurate observations of the fluorescent screen, as the eye is very slow to recover full sensitiveness.

The fluoroscope enables the operator to determine whether x-rays are being produced or not in the Crookes tube, and if produced, it enables him to decide upou their degree of intensity. Before taking a radiograph of almost any object, it would be well to examine it carefully with the fluoroscope.

The use of the fluoroscope, which is becoming more and

more general, supplies a new method of clinical investigation, which already renders undoubted service, and from which yet greater results can be expected. Its use at present is confined to the direct study of the living organism, since every shadow in the photograph is equally well revealed by it. The same results can be obtained with it as from a radiograph without the work of developing and printing a picture. The main thing about it is the experience required to see all that it reveals. The more one uses it the more he sees with it, and the more accurately does he see.

A great advantage which the fluoroscope has over the radiograph is the ability to observe the various organic movements by its means: such as the movements of joints and those of the heart and diaphragm. By means of this instrument it is possible to look directly into the body and see the skeleton with our own eyes, instead of taking radiographs.

The fluoroscope is an accurate agent for corroborating and extending diagnosis made by the ordinary methods. It is an invaluable aid in surgical and physical diagnosis. Foreign bodies, such as bullets, needles, etc., may be located in the flesh; fractures may be disclosed, or distinguished from dislocations, and the organs of the body, like the heart, lungs and spleen, may be outlined.

By means of the fluoroscope we can see the beating of the heart, the rise and fall of the ribs in respiration. The convexity of the arch of the liver can be outlined, and can be seen to rise and fall with expiration and inspiration. In fact there is not an organ in the human body that may not be seen and studied with the natural eye.

The fluoroscope gives a better assurance that the lungs are in a healthy condition than other methods; it gives earlier evidence of lung disease and more accurate information concerning its extent. It enables us to recognize more fully and accurately the degree, position and relation of areas of infiltration and condensation in pulmonary tuberculosis than can be obtained by means of auscultation and percus-

sion; also delineates plainly the limits of these areas. Emphysema, asthma, pleurisy, hydro-pneumo-thorax, pyo-pneumo-thorax, hydro-thorax and pneumonia, all are easily recognized and their limits demonstrated. In the last named disease it has been claimed that a more certain prognosis may be assured by the use of the fluoroscope.

PHOTOGRAPHIC PLATES AND DEVELOPERS

To take a radiograph by means of the x-rays, a sensitized photographic plate is, of course, a necessity. There are specially prepared x-ray plates, such as the "Hammer," the "Carbutt," the "Cramer," but it is not necessary to depend upon specially prepared x-ray plates. Select some one of the ordinary photographic plates that are on the market and adhere to the style exclusively. Personally I prefer the Hammer plate; also the Seed, 26x plate is a good one; these can be easily obtained at any photographic supply store. The size of the plates will vary, according to the size of the object to be radiographed—from 4x5 to 14x17. It is rarely that the larger sizes are required.

The plate may be placed either in an ordinary plate-holder which should be closed in the regular manner with a slide (not of metal), or the plate may be wrapped up in a piece of photographer's black paper, with sufficient folds to exclude light from both the sides and the ends.

A photographic plate has upon one side of it a hard, sensitized gelatine film. The film side can always be ascertained by holding the plate sideways toward the red light. The film side is dull, while the other side of the plate, being plain glass, has a bright and shining appearance. If still in doubt, the film side can be detected by moistening a finger and touching one corner of the plate. If the film is on that side it will feel sticky. Care must be observed, however, that the body of the plate is not touched with the fingers. It may be dusted lightly to remove specks, but never rubbed. Place

the film side uppermost. The reason for this is that the nearer the object to be radiographed is to the film, the clearer the definition will be.

Place the plate in position, then the object to be radiographed in its proper relation to the plate, then turn on the current. The current should never be turned on after the sensitized plate is brought near the Crookes tube until the operator has the object placed in position and is ready to make the exposure, as the rays will penetrate the plate covering at a considerable distance, causing the sensitized plate to become "fogged." Keep all new plates in another room where no x-rays can reach and fog them.

It is not necessary to open the plate-holder or other covering of the plate to make the exposure, as it can be made through the covering of the plate-holder or through the envelope covering the plate. With the plates in their holder flat upon the table, arrange the tube above them so that the radiant field will cover the plate perpendicularly.

A great deal of experimental work has been done to determine as to which was best to use, a "quick" photographic plate or a "slow" one; that is, a plate very sensitive to light effects or one not so sensitive. The results of these numerous experiments seem to indicate that an impression can be made upon a "slow" plate by x-rays in the same time as upon a "quick" plate, and that a "slow" plate may be really preferable, as there is less danger of its fogging; either may be used. The reason for this is apparently that it is not so much a question of length of exposure as to the quality of the x-ray being developed.

In order to obtain very short exposures some operators use a special photographic fluorescing screen between the film and the object; but as this is expensive many do without it.

METHOD OF DEVELOPING A NEGATIVE.*

It is a great advantage to an x-ray operator to develop his own pictures; he will naturally give them more care than a photographer would. The satisfaction of seeing the results grow under your own manipulation is well worth the extra trouble. It is, besides, a most useful guide in regulating future exposures. Very often a picture which has been *over-* or *under-*exposed can be developed carefully, and a splendid picture obtained. A photographer can tell you that your picture is over- or under-exposed, but it is impossible for him to express to you just how much or to what degree; while if you are accustomed to developing you can tell exactly how much it is over- or under-exposed in proportion to the length of exposure you have given it; then you are sure of getting a correct exposure on the second trial, provided that your tube gives off the same amount of rays and is placed at the same distance as with the first exposure.

The exposure having been made, the unopened plate-holder having been taken to the dark room, the next thing in order is to develop the plate. Any good developer may be used, but for general work the pyrogallic developer with carbonate of soda, or the metol developer are especially recommended. When strong vigorous negatives are desired, the pyrogallic is generally preferred, although by dilution and modification as much softness and detail can be produced as with any other developing agent. Metol is generally preferred, however, when soft delicate negatives are desired. The addition of hydrochinone to the metol solution produces more contrast or greater strength in the high lights. Personally I prefer the pyrogallic developer on account of its simplicity and its inex-

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* The sensitive plate after being exposed is called a "negative," because all the dense portions of the subject are shown as being transparent on the glass, and the transparent portions of the subject are shown as being dense on the plate. These relations are rectified, however, in the print, which in place of being a *negative* has become a *positive* view.

pensiveness. A fresh solution each time negatives are developed can be used, thereby always insuring a known standard strength; also, when a fresh solution is used each time the film will not frill, consequently chrome alum will not be required in the hypo or fixing bath. It is prepared as follows:

Pyrogallic Acid Developer, with Carbonate of Soda.

Solution No. 1.

Water,	30 ounces
Sulphite Soda crystals,	5 ounces.
Carbonate Soda crystals,	2½ ounces.

Mix; label the bottle A.

Solution No. 2.

Water,	24 ounces.
Oxalic acid,	15 ounces.
Pyrogallic acid,	1 ounce.

Mix; label bottle B.

Solution No. 3. (Hypo or Fixing Solution.)

Water.	4 parts.
Hyposulphite of Soda,	1 part.

This last solution may be simply a saturated solution of hyposulphite of soda, 12 ounces, filtered. Each one of the above solutions must be kept in a separate bottle and labeled so that there will be no liability for mistakes. To develop, take 1 ounce of solution No. 1, and ½ ounce of No. 2, and 3 to 6 ounces of water—more water may be used in warm weather and less in cool weather. Pour this developer solution into one clean tray, which should be marked to distinguish it, and never use it for any other solution than the developer. Light the ruby lamp, or, if a ruby colored window is used, light the lamp or gas jet, which is placed on the outside of the window, then darken the room and open the wrapper or plate-holder. Place the plate in the developer tray, film uppermost, rock the tray instantly, and keep the solution in gentle motion over the plate during the entire development. Bring the plate near the ruby light so that all changes in the film can be seen. Note the time. In two or

three minutes lift the plate from the tray and look at both sides to become accustomed to the gradual darkening of the film and development of the image. A slow, rather than a fast, development is desirable when details are sought, and sometimes six, ten or more minutes are taken for this process by manipulating the solution. When developing the negative, the first thing seen will be an outline of the object; if the hand, for instance, the flesh gradually becomes clearer; continue developing, if for hand, until the back of the plate has turned dark or nearly black, with the exception of the part which has the outline of the hand, but this should be somewhat dark; if the picture is through the body, continue developing until all the back of the plate has turned dark, then rinse and put in the hypo, film uppermost. The hypo tray does not require rocking. As the plate remains in the hypo the face which was at first white will gradually darken, and in twenty or more minutes will become entirely black. Until the last trace of white disappears the plate is not fixed. It does no harm to leave it five or ten extra minutes in the hypo clearing bath. The next step is washing the plate, which must be carefully done. Hold it under a gentle stream of cold water, tilted so that the water will flow over the entire surface for at least fifteen minutes. It can then be left in a clean tray, filled with cold water, with a stream running into it, so that the water is constantly in motion for about two hours. Remove, stand on edge in a cool place to dry. A plate requires a draught of air to dry well, but must be protected from dust. Always drain a plate into the tray from which it comes before rinsing. Always keep solutions cool. Never allow them to mix in the trays. The hypo solution must be freshly made when it becomes weak, but quite a number of plates can be fixed with one bottle of hypo. If at any time a plate frills around the edge, take it out of the plain hypo and add one drachm of powdered alum to harden the film. If chrome alum is used in the hypo the film will not frill. It is advisable, however, to use a fresh solution of Hyposul-

phite of Sodium each day during hot weather. The fresh solution hardens the film, and alum will not be necessary. During each step of the process the plates should be watched by the beginner for his instruction and future benefit. When the plates are dry, hold them to the light and note that the first one removed from the developer will lack "density" and be, perhaps, very faint. The plate which was developed longer will be much better, but to avoid errors of under- or over-development when practical work is afterward undertaken, the beginner should repeat the same experiment with two or more other plates, and in this way learn for himself in the most practical way it can be done the color changes in the plate which mark the acme of results.

The Metol Developer is prepared as follows:

Metol Developer.—Solution No. 1.

Water,	10 ounces.
Metol,	50 grains.

Dissolve thoroughly and add—

Sulphite of Soda crystals,	1 ounce.

Mix all and filter; lable the bottle A.

Solution No. 2.

Water,	10 ounces.
Potassium carbonate,	1 ounce.
Sodium carbonate,	2 ounces.

Mix and filter; lable bottle B.

Solution No. 3.

Bromide of Potassium,	1 ounce.
Water,	10 ounces.

Mix, filter; lable bottle C.

These bottles may be labeled A, B, C, and constitute a permanent stock. For immediate use, after standing a couple of days, mix in another bottle three parts of A, one part of B, sufficient to make twelve ounces, and add eight drams of C; this constitutes the developer. The fixing solution or hypo must also be prepared in a labeled bottle. It may be simply a saturated solution of hyposulphite of soda, prepared as given

under solution No. 3, in the formula above—the Pyrogallic Acid Developer.

In regard to the employment of the Metol Developer, the steps pursued in developing a negative are the same as those given for developing with the Pyrogallic Developer, with the following exceptions: A new solution will not readily "wet" a dry plate; therefore, when a solution has been freshly prepared a test-plate will have to be developed before developing an important radiograph. The developer may be poured back in the bottle and used again and again. All development should be begun with a weak solution, and the stock bottle gradually becomes weaker with use. It is strengthened from time to time when details do not readily come upon the plate by adding to it a half ounce or ounce of three parts of A and one part of B, mixed in a graduate before adding to the tray. When it is added to the tray always lift out the plate, pour in the strengthener, and rock the tray to mix the solution before replacing the plate. If at any time details come too fast, arrest them quickly by pouring about an ounce or less of the restrainer solution C. Then proceed to develop, and a little fresh strengthener can be added if too much restrainer was used.

PRACTICAL HINTS.

Ordinarily, signs of development will begin to appear within from three to five minutes; the parts of the plate where no object has intervened between it and the tube begin to darken, thus producing upon the plate a general image of the entire subject. If this be a portion of the human body no bones will as yet appear. Next; the image of the flesh begins to darken and in a like manner a shadow picture of the bones now appears as white lines. The image of the bones will remain white and distinct, and the development may be carried on to a point where the image is plainly visible even on the back of the plate.

The plate should be kept in the developing solution until its front has become quite dark, and until the image has apparently almost disappeared. After the plate has been in the fixing (hypo) solution for five or ten minutes the back of the plate, which was up to this time of a light color, will gradually become black the same as the front. The picture is then *developed* and *fixed*, and may be taken out into the light; but before being set up to dry should be washed for about half an hour in running or in clean cold water frequently changed.

At about the proper point of development the borders of the white side of the plate will begin to turn a brownish hue when examined by direct light. The fullest possible detail will then be visible to the eye and the plate is ready for the hyposulphite of soda solution—the fixing bath. This fixing bath takes from the plate all the sensitive chemical which has not been acted upon by the x-ray, leaving a permanent impression on the glass from which any number of prints may be made.

Plates when exposed too long are weak and uniformly gray, and only traces of an image are obtained. To improve an over-exposed plate, a few drops of a solution of Bromide of Potassium (one ounce of bromide to ten ounces of water) added to the developer will restrain its action, and may thus produce a good negative from what would otherwise be a worthless plate. More bromide will be necessary in the Metol Developer than in any other.

Negatives which have been under-exposed are full of delicate, ghost-like, yet clearly defined outlines of skin, muscle, tendon, and sometimes veins and arteries. When a plate has been under-exposed it should be removed from the normal developer as soon as its condition is known, and, without washing, place it in a tray of water where no light of any kind can reach it. If this treatment brings out the detail of the shadows where there has been but little action

of light in thirty or sixty minutes, it may then be developed in the normal developer, in a dark place.

If the development is continued too long, the negative will be too dense. If thoroughly fixed and washed it may be reduced as follows:

Reducing solution—No. 1.

Ferricyanide of Potassium, ...	1 ounce.
Water, ...	. 16 ounces

No. 2.

Water, ...	. 16 ounces.
Hyposulphite of Sodium, ...	1 ounce.

Keep solution No. 1 wrapped in opaque paper, as it is affected by the light. Take a sufficient quantity of No. 2 to cover the plate in a tray, and add to it a small quantity of No. 1; immerse the plate and watch it carefully. If the solution contains enough of No. 1, the reduction will proceed rapidly. If certain parts only of the negative are too dense, apply the reducing solution to those parts, while wet, with a pencil brush. Wash the plates thoroughly after this treatment.

If the negatives are too thin in high lights (high lights signify dark shadows on the negative and light places on the picture) to make satisfactory prints, it is usually the result of over-exposure, using the developer too much diluted with water, stopping the action of the developer too soon or from using the developing solution too cold. Such negatives may be strengthened by using an intensifying solution as follows:

Intensifying solution—No. 1.

Bichloride of Mercury, ...	. 60 grains.
Bromide of Potassium,	60 grains.
Water, .	. 6½ ounces.

No. 2.

Sulphite of Sodium, ...	. ½ ounce.
Water, ...	. 4 ounces.

Place the negative in solution No. 1 until bleached, then

rinse and place in solution No. 2 until nearly cleared; after which the plate must be well washed. This operation may be repeated if there is not sufficient intensity gained by the first treatment.

Negatives exposed to white light before the bromide of silver is thoroughly dissolved in the fixing solution will be foggy, and the printing quality will be injured.

The temperature of the developer is of just as much importance as the length of the exposure. A developer too warm will cause flat, foggy negatives. A developer too cold is retarded in its action, and causes thin negatives. The simple addition of a small quantity of boiling water, more or less, or a lump of clean ice to the water used in diluting the developer will readily control the temperature of the solution. Heat accelerates chemical action, cold retards it.

The quantity of sulphite of soda in the developer must be regulated to produce the color desired. If a developer made according to the formula produces negatives too cold and gray in tone, reduce the amount of sulphite until the quantity is found that produces the best color or tone. In many cases it may be reduced one-half and produce better results; in some cases it may have to even be increased.

In hot weather the quantity of carbonate of soda in the developing solution should be reduced, and in cold weather it is frequently necessary to increase it slightly. All developers should be made more dilute in warm weather than in cold, to avoid extreme density in high lights.

Common washing soda usually sold by grocers is not pure or uniform in quantity, and should not be substituted for carbonate of soda when making a developing solution. If possible, buy your chemicals of responsible dealers in photographic supplies and use the best. The best chemicals are always the cheapest.

Don't hurry development. Quick development means a lack of gradation, a forcing up of the higher lights before the less-exposed parts are acted upon. The roundness and grada-

tion necessary for good results are only attainable by slowly and carefully coaxing out the detail, so that all parts of the image come up fairly together.

Use plenty of developing solution to thoroughly cover the plate or plates. If an insufficient quantity is used, streaks, uneven development and general dissatisfaction will result.

Thorough fixing, thorough washing, followed by quick drying, will insure permanency and fine printing quality in the negative.

To prevent sand or rust from striking the negatives while washing, tie a piece of cotton flannel over the faucet. Cold water should be used throughout the entire process of developing. Two trays to hold the solution are necessary, one for the developer and one for the fixing solution (hyposulphite of soda). Neither of these trays should ever be used for any other solution than the kind first put in it. Single solution developers can be purchased from all dealers in photographic materials, who also sell the hyposulphite. Keep bottles well stoppered; otherwise you will be dealing with uncertainties.

Sulphite of Sodium should be kept in bottles with close-fitting glass stoppers, to protect it from the air, which will cause it to decompose and become worthless. In preparing developers pure water is very important. If water from well or hydrant is used, boil it and filter when cool. It is absolutely necessary to have a *dark* room in which to develop a negative. If the plates are in any way exposed to ordinary light they will be entirely ruined.

An undeveloped photographic plate should never be exposed to any but a ruby or orange-colored light. There are two methods of obtaining this light: (*a*) a small ruby or orange-colored window or one containing a combination of these colors; (*b*) a ruby lantern.

The window in the dark room should be about 12x18 inches, covered with orange-colored paper—commonly called post office paper. Use a lamp or gas jet outside to illuminate the window, as it is safer and more uniform than daylight.

This form of light is easier on the eyes than the ruby glass light, and by its use the quality of the negative may be more easily determined. If the operator prefers a ruby glass light, lanterns with ruby glass panes can be obtained at any photographic supply store.

It must be remembered, however, that there is no such thing as a perfectly safe light. Any light of sufficient illuminative power to be of practical use will affect a very sensitive plate, if given time enough; it is, therefore, necessary to use great care in developing.

Handle all plates by the edges or glass side only. Plates should always be kept in a *dry* room. The dark room, or developing room, is usually damp and poorly ventilated; for that reason it is not a safe place in which to keep gelatine plates.

If several plates are developed together in a large tray, the edges are liable to strike together, detaching small chips of glass which adhere to the soft gelatine surface; keep them separated by little strips of wood tightly fitted to the tray.

When plates are exposed and set away for future development, be sure to set them *face to face*, as they were in the original box. If the face or film is placed against the back, you will probably have finger marks on the film, caused by the fingers coming in contact with the back of the plates while placing them in the holder.

The operation of developing a negative is less formidable than it might appear from the above description and remarks. After a few pictures have been taken, however, it will be found that a radiograph can be developed and fixed usually within twenty or thirty minutes.

After a negative has been developed then the next step in the process is to have prints taken from it. It is better to turn this part of the work over to a photographer, unless the operator thoroughly understands photographic work. It may be added, however, that the negative itself constitutes the most perfect record of a case that the physician can either examine or preserve—no print is equal to the negative.

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